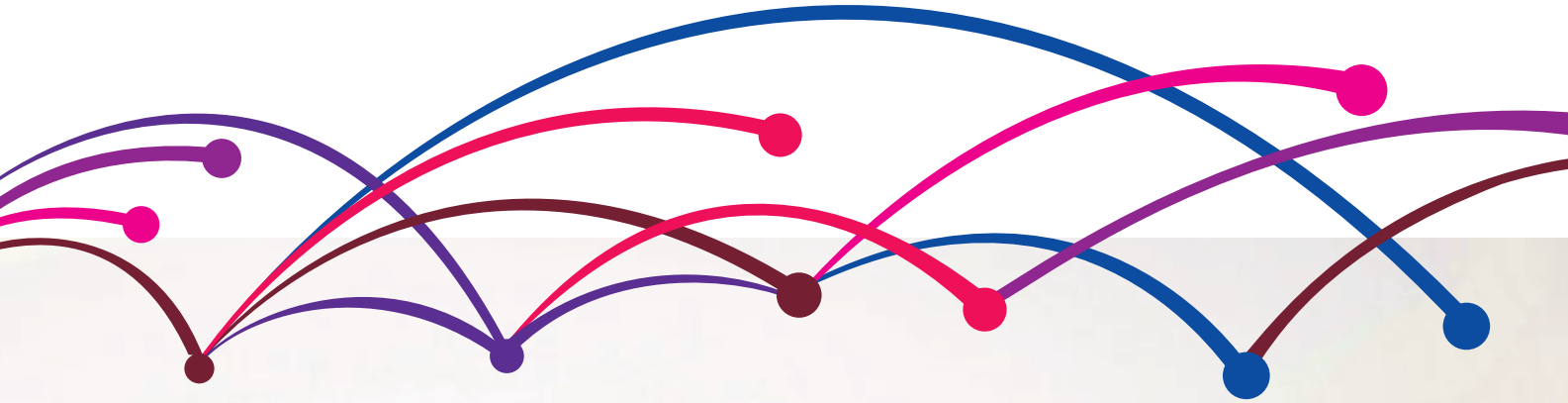
Researching:

Communications



Alliance of
Scientific Organizations

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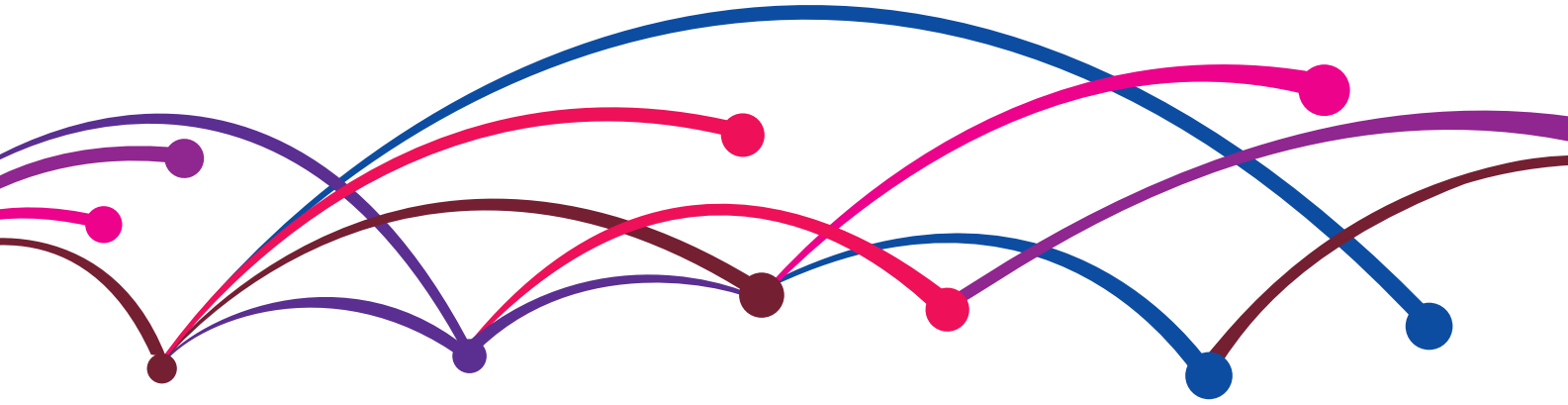
Researching:

Communications



Message of Greeting

In recent years the processes of innovation have gained significant dynamic force. The “High-Tech Strategy for Germany” has been a major factor in this. Introduced in the last legislative period, it constituted the first national all-embracing concept for the research sector and has led to a new quality of cooperation between the scientific, business and political communities. In developing the High-Tech Strategy further, proven measures will be continued, but new points of emphasis are also being accentuated. The “High-Tech Strategy 2020” focuses on five major areas: climate and energy, health and nutrition, mobility, security, and communication. The aim is to make Germany a leader in the solution of urgent global problems by giving impetus to new technologies and innovations and by pooling the resources of science and industry.

The members of the Alliance of Scientific Organizations have a key role to play in the successful implementation of the High-Tech Strategy. So that science can perform its central task in research and development, in technology transfer and in the innovation process, the federal and state governments have agreed to continue with the Pact for Research and Innovation, and to support the Excellence Initiative and the Higher Education Pact. Together, these initiatives represent the biggest investment in research, science, innovation and education ever seen in Germany.

The scientific organizations are successfully addressing issues of the future and are advancing into new areas of research. The current series of brochures shows how well German research is placed to deal with the major future challenges. Each brochure is devoted to one of the main subjects identified in the High-Tech Strategy and uses engaging examples to illustrate the work conducted in Germany’s research institutes. With their easy-to-understand descriptions of advanced research, these publications support the broad dialog with the public on the pressing questions of our time.

Prof. Dr. Annette Schavan, MdB
German Federal Minister of Education and Research

Preface

Ladies and gentlemen,

Human beings are highly communicative creatures. In the course of our evolution and across our many cultures, language and writing have always been two powerful instruments for entering into a dialog with others. And yet, the enormous possibilities opened up to us today by digital communication would probably have left us speechless with astonishment just twenty years ago.

Today, it is matter of course for us to use the Internet – whether to mail, blog, twitter, or skype. Social networks enable us both to find new friends anywhere in the world and to meet up with old friends around the corner using our cell phone location function. Where before we had to go to the library or purchase expensive books to look up certain topics, we can now do it from home using free online encyclopedias and downloading data from the "cloud." In personal, economic and social terms, the effects of these developments are immense, and it is often hard to predict what twists and turns the journey will take next. In the global community's virtual network, the digital revolution is also making real-life revolutions possible, because even citizens of dictatorships are able to exchange information and organize themselves democratically despite all attempts at censorship.

The latest information and communication technologies have long since begun to change the world around us by giving objects the capacity for language – to the benefit of us all. Highly complex sensor networks and self-organizing systems operate unnoticed in the background, organizing traffic flows, monitoring power grids, controlling production facilities or functioning as ecological early-warning systems. Soon, perhaps, autonomous interactive robots will be creating three-dimensional maps of other planets for us. Digital communication has made all aspects of our world more mobile, more interesting, more comfortable, richer, and faster, and it has expanded our knowledge of that world to an unimaginable extent.

Scientists of all disciplines and from all parts of Germany are working intensively to ensure that the dialog between human beings and the objects around them functions smoothly and, in certain areas, almost intuitively. The tools at their disposal include ever more efficient broadband technologies and highly complex processor architectures, peer-to-peer and overlay networks, and embedded systems. They are developing new mobile communication and information management strategies as well as platforms for e-government, e-learning, e-research and e-business; ways to allow the digitization and long-term archiving of our cultural heritage; and innovative solutions for the Semantic Web, cognitive systems or human-machine communication. They are searching for answers to the many questions concerning security, data protection, copyright or property raised by the risks inherent in digital communication – risks which, despite all the benefits, undeniably exist.

It goes without saying that science itself can make use of the advantages already offered by digital communication. Buzzwords such as open access, virtual research environments or high throughput analysis are merely some notable examples of the broad spectrum of new possibilities.

The high level of expertise, innovation and commitment with which scientists at German universities and research institutes are tackling the many challenges posed by digital communication is described in this brochure. It was put together by the Alliance of German Science Organizations under the leadership of the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) and uses selected examples to illustrate the topic at hand. It is available both in printed form – a medium that has an almost nostalgic touch – and as a more modern PDF download from the Internet. Ideally, it will act as a basis for interesting discussions between you and your colleagues and friends – which in turn will hopefully give rise to further productive dialog.

Sincerely,

Matthias Kleiner

Prof. Dr.-Ing. Matthias Kleiner
President of the DFG

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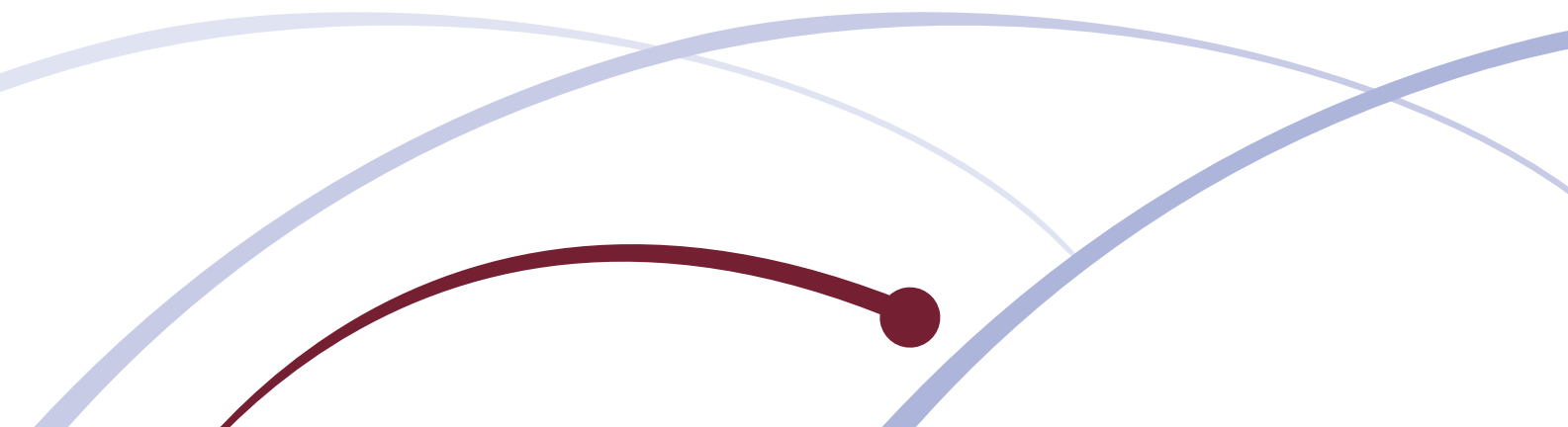

1 Dialog of computers

Computer networks

Businesses wanting to remain competitive in the information and communication technology sector have to be able to offer technologies and services that can be deployed across all different platforms. In technical terms, that calls for powerful databases and network architectures. Experts in communication-systems research are currently working flat out to deliver the required technologies and define the necessary standards.

Complex network architectures are the backbone of digital communication.

Users today take for granted the ability to call up and exchange files, information and documents using PCs and smartphones – irrespective of the manufacturer and operating system of their devices.

In future, this form of convergence will extend to include all types of devices: computers, smartphones, TVs, sensors as well as onboard systems in motor vehicles will then be able to interact without media discontinuities and to access information made available in virtual form via secure data lines.

In addition to services that can be deployed across different platforms, it is above all databases and network architectures that enable individual parties to work together in an interoperable, seamless manner. Innovative network architectures need to enable end-user devices, computer systems and networks to link up in all possible combinations. Integrated heterogeneous environments of this type allow users and devices to network flexibly as required and make it possible to provide the necessary services.

High-performance Computing
Supercomputer infrastructure for Europe

Under the auspices of the Partnership for Advanced Computing in Europe (PRACE), 20 European countries are building a distributed supercomputer infrastructure. This makes extremely high-performance computers available for top-class research work across the continent, in fields as diverse as climate change, sustainable energy supply and health care. These computers are connected to each other via a high-performance optical-fiber network built through the EU's DEISA project. The UNICORE grid software, developed under the leadership of Forschungszentrum Jülich (Jülich Research Center), grants researchers – no matter where they are located – easy access to the various computers in the infrastructure. A partner of the Gauss Centre for Supercomputing, Jülich is spearheading this initiative.

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Exascale Computing
A new dimension in computing

Under the leadership of the German Research Foundation (DFG), the Heads of Research Councils of G8 countries (G8-HORCs) have launched the Exascale Computing Initiative to focus on the mainframe computers of the coming decades. Compared with the fastest computers currently in operation, the new computers will be able to execute up to one thousand times the number of mathematical operations in the same time. In order to achieve this, an entirely new scientific approach needs to be taken to programming these mainframes. So the initiative is promoting multilateral projects which deal with research into and utilization of "exascale-capable" application software.

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1 Dialog of computers

One of the most energy-efficient mainframe computers in Europe is located in Frankfurt am Main.

When it comes to network architectures, peer-to-peer technology is a popular concept. In this context, a "peer" is a participant. The technology links up all participants and accords them equal status – in contrast to the hierarchical approach taken in traditional client-server networks. Every peer can make services available within the network and utilize those provided by the other peers.

Peer-to-peer networks are based on IP (Internet Protocol) technologies, which use the Internet as their platform and form a superimposed virtual network. Peer-to-peer networks are employed, for example, in grid computing or car-to-car communication; virtual communities also use them, for instance as a platform for distributed development work. Networks of this type are relatively cheap to provide and enable information to be exchanged in a very fast and effective manner, which is what makes them such an attractive proposition. According to a study carried out by Ipoque, a European provider of Internet traffic management solutions, around 52 percent of all Internet traffic in

Cloud Computing

Software from the stratosphere

Researchers, businesses and private users are producing ever larger amounts of data in the web. Although this data contains valuable information and, for that reason, is worth keeping, the sheer volumes involved mean they can no longer be processed by individual computers. In the Stratosphere project, which is being funded by the German Research Foundation (DFG), database researchers from several universities in Berlin and Potsdam are examining new methods that make it easier to harness the computing power of large computer clusters, for example to evaluate climate change models or to analyze large amounts of text. The technologies they are developing for virtualization and parallelization in the "cloud" enable users who do not have their own computer centers to carry out complex analyses in a cost- and resource-efficient manner.

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Parallelization

Making overlay networks more stable

In the information age, interactive systems and platforms such as social networks and peer-to-peer systems offer undreamed-of possibilities for the effective exchange and rapid dissemination of information. These systems use the Internet to create an appropriate network of connections, which is known in the field as an overlay network. Interactive systems of this kind, which are often accessible to everybody, are both highly dynamic and open to attack. In order to achieve a high level of stability, a project at the University of Paderborn funded by the German Research Foundation (DFG) is developing procedures that will enable overlay networks to always achieve and maintain the desired network structure from any point, thus preserving the system's functionality.

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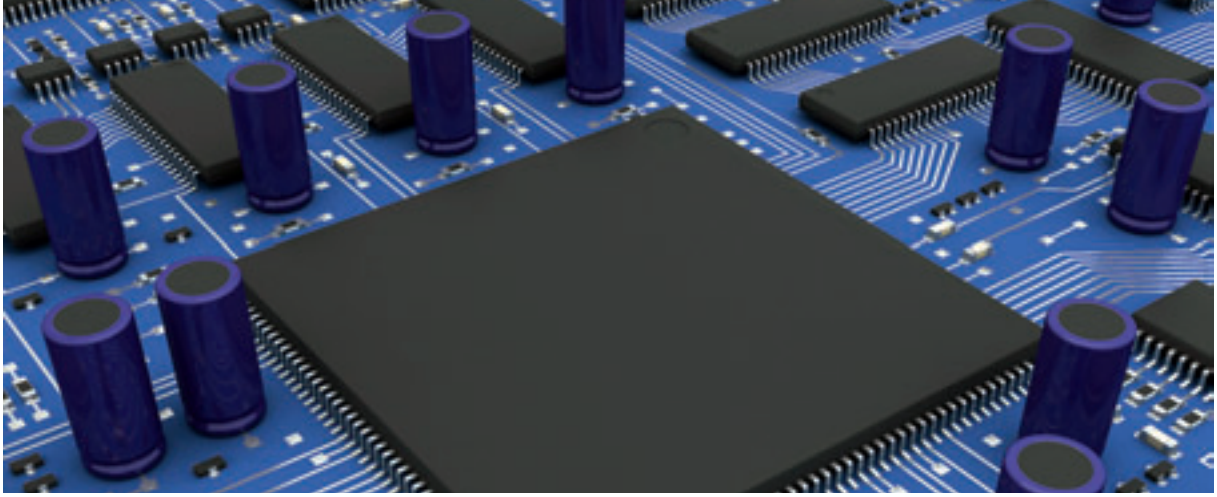

Embedded systems form a core component of technical products, for instance in the transportation industry or the medical technology sector.

Germany in 2008 was carried out via peer-to-peer networks. But the rising volume of traffic calls for ever more efficient quality assurance, and providing suitable technologies for this is the focus of current research in this area.

Embedded systems – where self-contained computer units are integrated into a different technical system – constitute another successful idea. As a rule, embedded systems take the form of a combined implementation of hardware and software, bringing together the flexibility of software with the high performance of hardware.

These computer units handle diverse tasks, such as controlling and monitoring the system in which they are embedded, quality control, signal and data processing, and enabling interaction between the system and the outside world via defined interfaces or protocols. Embedded systems perform their services in numerous application areas, including aircraft, motor vehicles and consumer electronics.

Peer-to-peer technology
Improving service quality

In recent years, the peer-to-peer paradigm has grown in significance – Skype and P2P streaming being just two prominent examples. The performance of a P2P system is solely dependent on the resources of the participants. But as they interact autonomously, their behavior cannot be predicted. That is why it is impossible to fully guarantee system service quality. The objective of the German Research Foundation's QuaP2P research group is to create a deeper understanding of quality in these systems. In addition, through systematic benchmarking the researchers intend to identify the limits of P2P systems and, in the long term, to derive from these limits design principles for future protocols and technologies.

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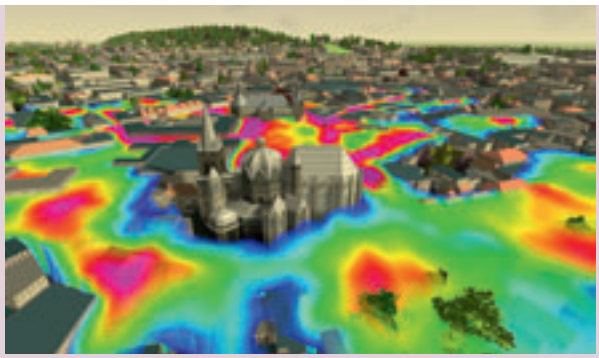

Mobile communication
Serving the user

The current bus timetable, a quick price comparison or the latest e-mail – thanks to laptops and smartphones, WLAN and UMTS, the Internet now follows us wherever we go. And yet, users still encounter many obstacles when using mobile applications. How, for instance, to work and communicate using a fixed-line or wireless connection or even without any network connection at all? How to make simple, reliable and secure use of the vast number of private wireless LANs? And how to protect our privacy given the masses of data being collected by all the cameras, microphones and sensors that surround us? In numerous projects funded by the German Research Foundation (DFG), researchers at RWTH Aachen University are working to find answers to all these questions.

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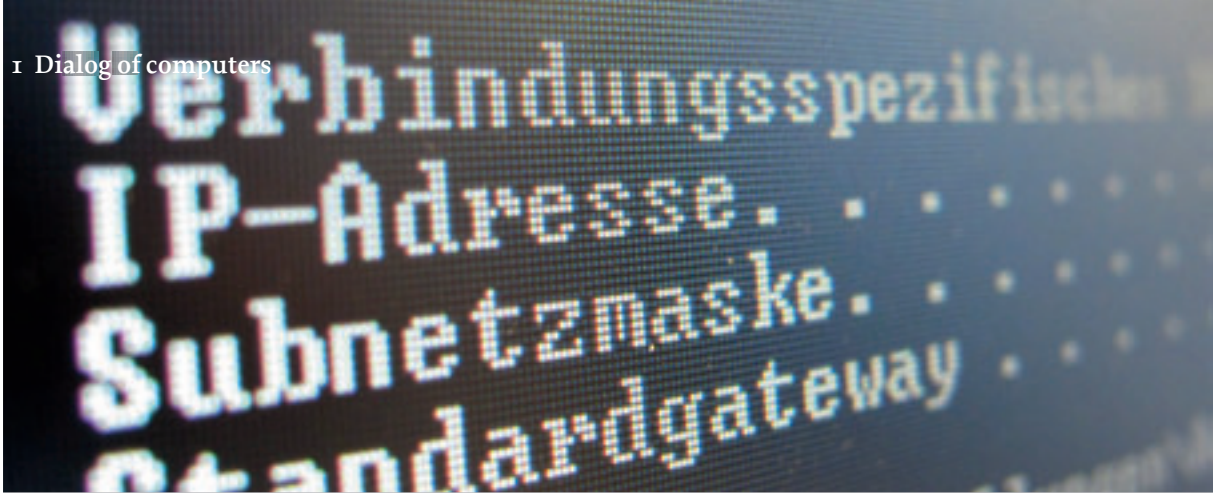
1 Dialog of computers



IP addresses help computer networks to organize the dialog between their constituent parts.

Standards constitute the technical basis not only for the seamless integration of embedded systems, but also for keeping communication and interaction across IT networks and between applications free of media discontinuities. The specifications – which are the result of the standardization process – set down the binding features that a system must respect. This kind of harmonization and systematization is essential for trouble-free, interoperable interaction between components, helping to ensure the quality of both the services and the software.

Internet protocols (IP) represent one of the most important technical standards. IP addresses can be used to group together computers and end-user devices within a network to form a logical unit. This makes it possible to address computers within large networks and to establish connections with them.

Version 6 of the Internet Protocol (IPv6) was introduced in early 2011 to supplement the fourth version (IPv4). While IPv4 enabled a total of some four billion IP addresses, IPv6 enlarges this address space by

Free data traffic
Glasnost on the Internet

With their Glasnost project, scientists at the Max Planck Institute for Software Systems have created more freedom in data traffic. A freely available software application allows users to check whether Internet providers are restricting or even blocking data packets of popular applications such as BitTorrent. More than 750,000 users have already used the software. In the process, it has become evident that more and more major service providers in Europe and North America are surreptitiously restricting network traffic in this way. Authorities responsible for regulating data traffic in a number of countries have expressed an interest in the data collected by the Glasnost project for the purposes of their own investigations.

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Information management
IntegraTUM – seamless and user-friendly

The purpose of IntegraTUM, a project funded by the German Research Foundation (DFG), was to implement a seamless and user-friendly infrastructure for information and communication purposes. To this end, operations were recentralized using the latest technology, with the faculties and institutions still maintaining decentralized responsibility for content and processes. Through a combination of technical and organizational measures, redundancies in technology, data and responsibilities were reduced and the supply quality improved. New services such as the campus-wide e-learning system and MediaTUM media server have honed the university's profile and improved the foundations of both research and teaching.

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Routing is impossible unless computers can be logically addressed via an IP address.

a factor of 296. This much greater number of IP addresses was needed to meet growing demand, to improve the structure of Internet addresses and to enhance the performance of Internet routers. Logical addressing forms the basis of routing, i.e. determining the path that network packets take through the Internet and moving them on their way. If a device or communication network meets the technical requirements to establish IP-based communication connections, it can join the network, and can receive, provide and send data. This approach turned the centralized mainframe network into a horizontal, flexibly expandable network that can be used in countless applications.

Standardization processes and the interoperability of communication systems they bring about are opening up new business and operating models. One of the latest strategies is cloud computing, in which services, software and computing power are provided from a central "cloud."

Information management
MIRO – making knowledge available faster

The efficient provision and effective management of information are already basic prerequisites for forward-looking research and teaching at university level. Apart from fast and easy availability of content, it is essential that it can be properly used for the task at hand. With this in mind, Münster University is developing MIRO, a comprehensive information management system for scientific and organizational content that combines a uniform mode of access and personalized modes of distribution.

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Embedded systems
Better onboard software

Whether they are designed for driving safety, telematics or energy efficiency, automotive control systems have to be reliable if they are to afford passengers the highest levels of safety and comfort. In order to optimize testing of these systems' underlying software, experts at the Fraunhofer Institute for Open Communication Systems FOKUS have joined together with partners to develop the new standard "Testing and Test Control Notation embedded" (TTCN-3 embedded), which is designed to support the automotive industry particularly in testing safety-critical systems. The technology enables the safer, more efficient and cost-effective design of quality assurance processes for software components.

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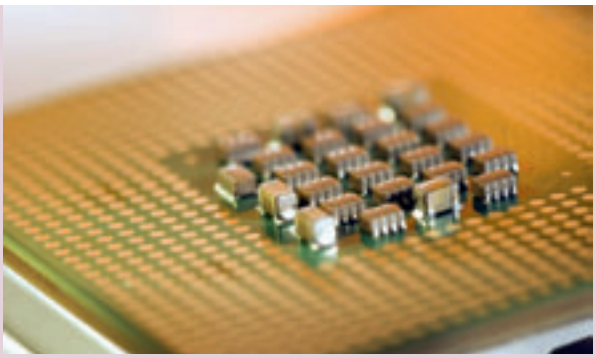
1 Dialog of computers

Cloud computing helps to lower IT costs, making it an attractive proposition for private enterprise and the public sector alike.

Companies and organizations do not have to purchase servers and software solutions themselves. Instead, they lease the required capacity for data, computing power and applications from professional providers. It is a flexible – and economical – solution because you pay only for what you use.

The latest economic data already reflect the attractiveness of cloud computing. According to a study published in April 2010 that was carried out by the Experton Group on behalf of BITKOM, Germany's Federal Association for Information Technology, Telecommunications and New Media, revenues from cloud computing in Germany are set to grow from 1.14 billion euros in 2010 to 8.2 billion euros by 2015. The forecast implies that this technology will account for some ten percent of the country's IT expenditure five years from now.

Thus far, companies have been the main proponents of cloud computing, but the public sector too is beginning to show increasing interest, as a study carried



Embedded systems

Protection against rapid aging

The ongoing miniaturization of highly integrated circuits is having undesired effects, such as premature aging or higher sensitivity to cosmic radiation and fluctuations in temperature, which can jeopardize the functionality of embedded systems. The goal of the Design and Architectures of Reliable Embedded Systems program funded by the German Research Foundation (DFG) is to combine innovative hardware architectures with software to achieve a high level of reliability for future technology generations. The results of this research are of relevance, for example, to the automotive and consumer electronics industries.

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Smart Grids

Intelligent integration of electric vehicles

If electric vehicles are to be integrated efficiently into the energy system, there needs to be an intelligent infrastructure for charging the vehicles and feeding back electricity. MeRegioMobil is a research project under the auspices of the Karlsruhe Institute of Technology, the Fraunhofer Institute for Systems and Innovation Research ISI, EnBW Energie Baden-Württemberg AG, Adam Opel GmbH, Daimler AG, Robert Bosch GmbH, SAP AG and Stadtwerke Karlsruhe. Its objective is to develop and test key technologies and services for the integration of electric vehicles into existing and future power grids and traffic networks using the latest information and communication technology. MeRegioMobil forms part of the ICT for Electromobility development program funded by the German Federal Ministry of Economics and Technology in conjunction with the German Federal Ministry for the Environment.

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Cloud computing poses new challenges as regards communication security.

out by the Fraunhofer Institute for Open Communication Systems FOKUS and the Hertie School of Governance reveals: cloud computing, says the study, holds great potential for modernizing public-sector information technology and computer centers as well as for consolidating IT resources.

That is why the German Federal Ministry of Economics and Technology has launched a cloud computing action program to promote the utilization of Internet-based IT infrastructures and IT services.

Since public authorities are required on principle to protect the personal data that citizens entrust them with, the use of cloud computing in public administration hinges upon whether data security can be guaranteed. For this reason the federal ministry is pushing research into and development of technologies to optimize security and thus reinforce confidence in cloud computing solutions.

Audio and video encoding

Focusing on what is important

Uncompressed media files are very large and use up a lot of capacity in both storage and transmission. Without encoding systems – which reduce the amount of data without restricting its quality for the consumer – it would not be possible to use these media to the extent we are accustomed to today. In the realm of audio data, the mp3 and AAC formats have gained currency all over the world, while for video data the standard is H.264/MPEG-4 AVC. Researchers at Fraunhofer Institutes played a key role in the development of both these video and audio encoding systems, which have proved crucial to the success of new media technologies such as mp3 players, satellite radio, HDTV as well as the Internet and mobile TV.

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3-D visualization

Real objects in a virtual world

Anyone wanting to transfer the image of a real object such as an automobile to a computer currently requires expensive laser scanners. But the new process for 3-D scene analysis developed by the Max Planck Institute for Computer Science, which makes do with an off-the-shelf video camera, is much faster and cheaper. Users merely need to film the object by walking around it once and then load the 360° video sequence onto the computer. The software processes the data to create a 3-D object that can then be built in to film scenes or video games. The quality of such image-based processes has often been quite poor in the past, but this new process makes it easy for users to correct the 3-D object on the computer, considerably improving the quality.

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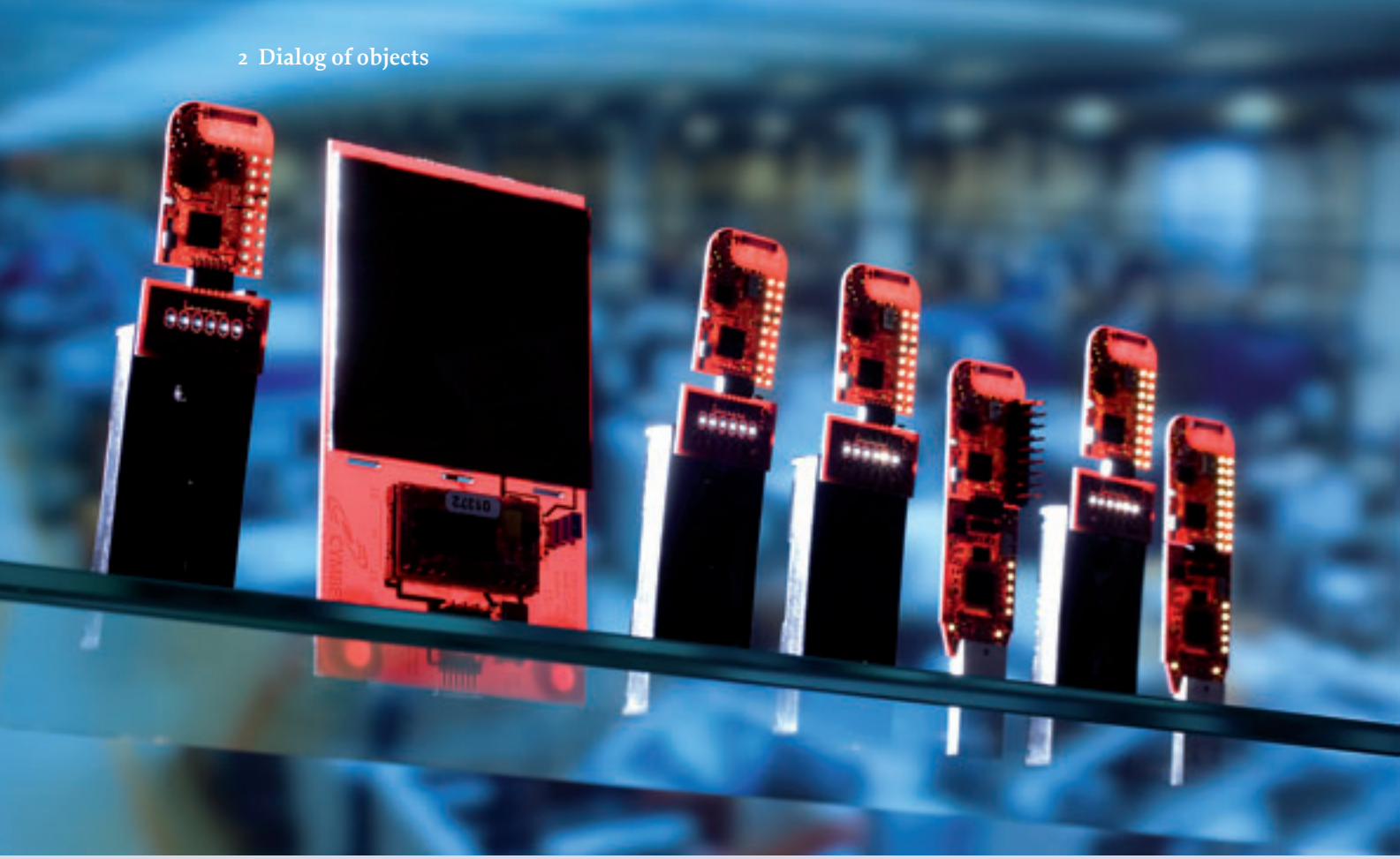

Intelligent objects

The world of objects surrounding us is exceptionally diverse. It ranges from a “dumb” bag of potato chips to the sensor networks, agile robots and complex interactive systems found in the production and transportation sectors. Intelligent objects provide information on their status, take in and record their environment, and coordinate autonomously with like objects. This “dialog of objects” has the potential both to relieve human beings of less creative work and to improve the utilization of natural resources. Scientists across Germany are working to expand this dialog.

With the aid of wireless networks, measured data from different sensors can be displayed on any kind of device.

In many areas we have already grown accustomed to the fact that "inanimate" objects communicate with each other. The transfer of the temperature reading from the outside thermometer to the display unit in the living room can be described as monological: the former transmits, the latter receives. This process forms the basis for sensor networks, by means of which we can collect more or less complex information about our environment, for instance on the status of production and transportation systems or on patients' state of health.

Sensors are usually inexpensive and are becoming increasingly widespread. The range of their wireless signals is typically anywhere between just a few centimeters to several hundred meters. There are also big differences in their data rates, i.e. the rate at which they send their so-called telegrams. Both of these parameters are determined by the distance to the receiver being addressed and its dynamics as well as the sender's power supply system. The outside thermometer sends its temperature readings once a minute and has to bridge a distance of only a few me-

The Internet of Things
Networking objects

The term "Internet of Things" is used to describe the virtual networking of industrial and everyday objects. The applications involved are geared in particular to controlling power grids, to the topics of well-being, aging and health care as well as to the logistics sector. Under the auspices of the EU-funded Internet of Things Architecture project, the Fraunhofer Institute for Material Flow and Logistics IML – together with partners from industry (including SAP, IBM and Siemens) – is carrying out research into the fundamental architecture of the Internet of Things. The goal is to create a reference model, similar to the IP protocol for the Internet, by developing the technical specifications (protocols, interfaces and algorithms) for a cross-application Internet of Things.

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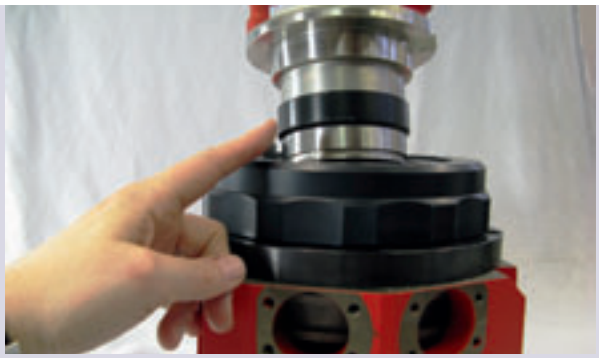

The Internet of Things
Radio signals through metal

Metal blocks radio waves – even where this effect is not desired. This applies to RFID chips, for instance, which are supposed to transmit information to a reading device via radio signals. Now, researchers at the Fraunhofer Institute for Microelectronic Circuits and Systems IMS in Duisburg have become the first to find a way of integrating RFID chips in metal tools. On demand, these miniature data storage units send the required information to a reading device outside the metal spindle that holds the tool and the adapter. This transmission method can be utilized wherever information has to be transferred in wireless form over several different routes, such as in robotic arms with swivel joints.

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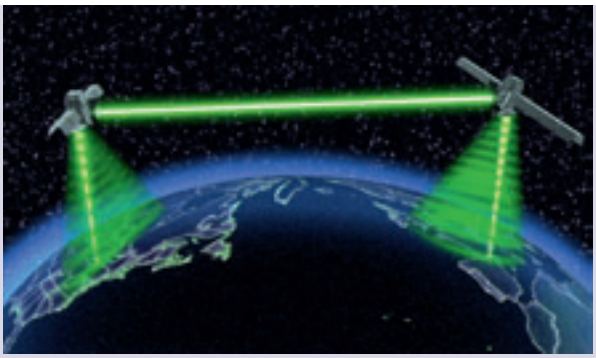
Interconnected automotive assistance systems warn each other about roadworks or traffic build-ups.

ters. A stationary vehicle at the tail end of a traffic jam on the freeway ought to be able to alert vehicles further back of its status so that they can brake in time. The warning is sent "blind" and there is no feedback channel.

That means that the sender knows neither whether another vehicle correctly received the telegram, nor whether such a vehicle is even approaching the end of the traffic jam. Success can only be guaranteed if the range of the sender, the repetition rate of the telegrams and the transmission process are all optimal. If the sensor density, the range and the telegram rate are all high, transmission of the radio signal can break down. That is why it is important to transfer only the data that substantially enhances the information content. A few systems already provide for a mild form of data adaptation. The Extended Floating Car Data (XFCD) system, for instance, has control parameters that use a random generator to reduce the volume of data on traffic, weather and road conditions collected from vehicles' onboard systems until the data for



Optical satellite communication
Laser technology for outer space

The Ferdinand-Braun-Institut (FBH) develops powerful, energy-efficient components for modern communication systems, including ground-breaking laser technologies for optical satellite communication. Laser modules produced by the FBH are extremely stable and meet the stringent quality requirements for use in space. Thanks to their extremely low noise emissions, these modules ensure that data is transmitted between satellites and to Earth free of error and at a high bit rate. In fact, transmission is one hundred times faster than with conventional radio signals. The first modules installed for test purposes in operational satellites have already convincingly demonstrated these characteristics. In the future, this technology will enable images to be sent from Mars to Earth in real time.

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Optical satellite communication
High-resolution environmental data

The mobility we enjoy today would be inconceivable without wireless communication. However, the transmission bandwidth available is limited, a fact that is already triggering battles to secure this scarce resource of the information age. Free-space optical communication may offer a way out of this impasse. This technology enables much higher transmission rates than would ever be possible with radio signals. At the Institute of Communications and Navigation of the German Aerospace Center (DLR), corresponding technologies are being developed that will be able to transmit between one hundred and one thousand times more data than current radio systems. This will enable tomorrow's environmental satellites, for instance, to transmit high-resolution data to Earth without interruption.

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Terrestrial and satellite data can be combined to protect against environmental dangers.

each stretch of road is sufficient, but not excessively dense. In the field of patient monitoring, too, the signals emitted by sensors are initially processed and the situation assessed locally before – in the event of abnormalities – comprehensive data is transmitted to the control center.

The growing number of sensors that surround us provides us with an ever more precise image of the physical conditions of our environment and the degree to which it has been "settled" by people and objects.

These local readings are supplemented by data gathered by satellites, which are transmitting images to Earth in ever higher resolutions. The huge bandwidths required for this pose a big challenge for researchers. But it is work that pays off: the combination of terrestrial and satellite data provides information of the status of the Earth's weather, vegetation and watercourses; it enables an accurate assessment of the effects of building projects, farming and other types of land management; and it helps to protect people, the environment and material goods.

Traffic management

Efficient management of traffic flows

Whether on roads, railways, waterways or in the air, the volume of traffic is constantly rising. Making sure that traffic flows smoothly, efficiently and safely in future calls for intelligent traffic control. One promising approach comes from the air traffic control sector; it views aircraft as nodes in a network in which they are to be connected with each other by means of a variety of transmission technologies, for example via ground- and satellite-based communication and/or ad hoc networks. Networking systems of this type, which are to be introduced in aviation in the medium term, also hold enormous potential for land-based and maritime traffic.

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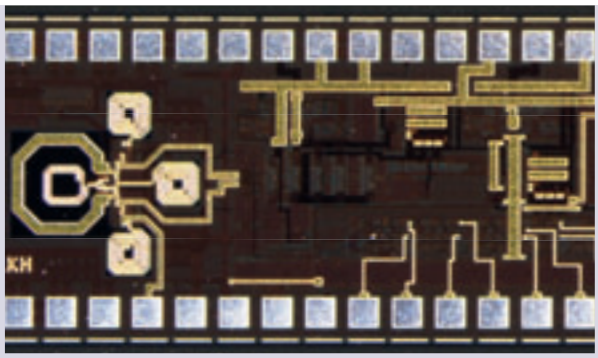

Broadband communication

Gigahertz electronics for flexible payloads

Broadband communication via satellite – such as HDTV for instance – is a rapidly growing market. In this field, frequency synthesizers provide the frequencies required for the radio channel. Up to now, these synthesizers have been used in communication satellites with a fixed frequency. However, in order to ensure that the hardware remains programmable throughout its entire 15-year life cycle, the frequency synthesizer needs to be tunable over a wide frequency range. Further demands made on this circuit include high frequency stability and robustness against cosmic radiation. Suitable chips have been developed at the IHP – Innovations for High Performance Microelectronics and manufactured using the institute's own SiGe BiCMOS technology. These can help to reduce both the weight and cost of satellite payloads.

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2 Dialog of objects

When scanned, an item's packaging "betrays" its price and content.

Back on Earth, the "dialog of objects" takes on different forms in our everyday lives. It starts at the supermarket with the scanning of the barcode on the bag of potato chips. This may seem to be simply a procedure for registering the price in the POS system. But in the background, it causes the supermarket's inventory to be adjusted accordingly and – once a minimum quantity has been reached – a replacement order is triggered.

It is also conceivable that a customer's smart card could be used to compare a product's ingredients with a list of allergens and then recommend or warn against its purchase. The barcode is the link between the content and the information space.

If an automobile's sensors register a patch of ice on the road surface, the location (as identified by GPS) and a warning are sent to an information space, from where the message can be accessed by other vehicles. The message can be either called up centrally or passed on directly from vehicle to vehicle in the manner of an informal "chat."

Wearable electronics

The vest that feels with you

How stressed are we? This is a question that a new sensor vest will soon be able to answer. From sports training to computer games, the garment registers the electrical excitation of the muscles at any given time and determines the level of physical stress. The vest is being developed by companies and research institutes as part of the EU's CONTEXT project. At the core of the vest is "wearable electronics" designed by the Fraunhofer Institute for Reliability and Microintegration IZM. The system could potentially be applied in occupational health and safety, in sport medicine, and to control computers without the customary input media of keyboard and mouse.

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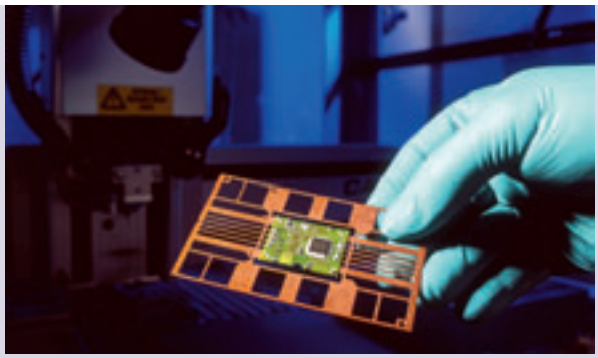

Medical management

Sensor networks for hospitals

A sensor network is a system of spatially distributed sensor nodes that can communicate autonomously with each other and with existing infrastructure using radio signals. Unlike technologies such as RFID, communication within wireless sensor networks is active and bidirectional, which opens up whole new fields of application. The purpose of the OPAL Health project is to improve clinical processes such as the management of medical equipment, the monitoring of blood products and the safety of transfusions via a single technology platform. The system comprises so-called smart objects – i.e. ones equipped with communication-capable modules – that are based on the s-net® technology for wireless sensor networks developed by the Fraunhofer Institute for Integrated Circuits IIS.

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Today's complex logistics processes would be unthinkable without modern ICT.

The underlying mechanisms for this need to be designed in such a way that the information stays accessible for a sufficient amount of time, but is deleted again from the information space as soon as the ice on the road has melted.

In the case of both the bag of chips and the sheet of ice, one object is looking at another: the scanner is monitoring the bag of chips, while the vehicle is monitoring the area through which it is being driven. The method used to address the information is an indirect one – an approach on which many logistics solutions and transport processes are based. If, for example, a pallet at storage space E47 is to be delivered to the distribution center of an electronics company in Munich by tomorrow evening, the entries made in a list of transport requirements – in combination with the determined time – will trigger its dispatch. This kind of dialog can be refined in such a way that an active object can recognize another object and its dynamic state and derive from this information an appropriate response. In very broad terms, human-machine

Sensor networks

Monitoring electricity

As more and more electricity is generated from renewable energy sources, the demands made on power grids are set to rise. Load monitoring – by means of energy-autonomous sensors that communicate independently – can optimize transmission capacity and enhance the reliability of the power grid. In conjunction with research partners and under the aegis of envia Verteilnetz GmbH, a distribution grid, scientists at the Fraunhofer Institute for Reliability and Microintegration IZM are developing a system of this kind for overhead lines. In particular, the system monitors the temperature of the conductor ropes so as to ensure maximum current flow through the lines while observing the permissible sag. The energy-autonomous sensors thus provide the local data basis for load monitoring.

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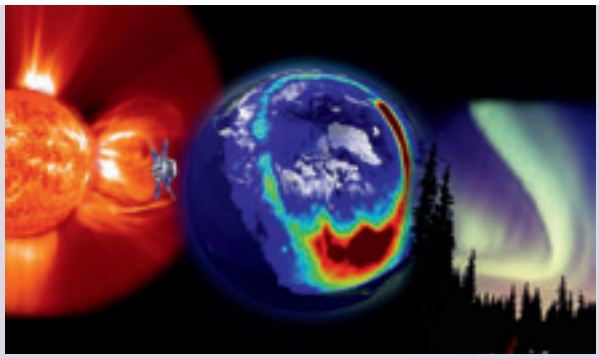

Sensor networks

Protection against dangerous weather in space

State-of-the art technological systems are vulnerable to the dangers posed by space weather. The functionality of communication and navigation systems can, for example, be seriously impaired by radio signal interference in the ionosphere. That is why scientists at the German Aerospace Center (DLR) are involved in the construction and operation of modern satellite- and ground-based sensor networks. They use the data gathered by these networks to develop innovative technologies and models for the global capture of space weather data and for making weather forecasts. The information derived can serve to characterize the ionosphere and is made available to interested users in near real time via the SWACI information and data service.

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2 Dialog of objects

In an experiment, an aerial drone of the German Aerospace Center (DLR) examines algorithms for autonomous intelligent functions.

interaction via language and gestures belongs to this category.

One of the more common forms taken by the "dialog of objects" is between devices and their manufacturers in the case of automatic updates. The purpose of this dialog is crystal clear and its level of complexity rather low. But in the case of automatic testing of electronic devices, the communication is rather more diverse. The tasks at hand are distributed between the test system and the test object, which enables testing to be carried out much more quickly. The course of the dialog is influenced by the interim test results at each end.

The safety-critical dialog in the collision avoidance systems used in the aviation industry is as symmetrical as possible. In dialogs of this type, clear, unambiguous agreements are reached about the action to be taken in a particular situation. The algorithms and protocols on which this communication is based are narrowly defined so as to maximize the probability of accident

Electronic patient monitoring

A doctor on hand anytime

Doctors are increasingly requesting that the vital data of chronically ill patients be monitored on a continual basis. In cooperation with the Distributed Artificial Intelligence Laboratory of the Technische Universität Berlin, researchers at the Fraunhofer Institute for Reliability and Microintegration IZM developed a system to individually monitor and record a patient's vital data – pulse, blood oxygen saturation and body temperature. The data are transmitted in real time via Bluetooth to a host system, where they are evaluated. What is more, an integrated GPS module ensures that the test person can be located at any time. This constitutes a big step forward in terms of safety, especially for elderly patients.

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Self-organizing microsystems

Miniature components control machines

The self-organizing capability of miniature electronic components – known as e-grains – opens up fascinating perspectives for production facilities. The vision of a project funded by the German Federal Ministry of Education and Research is that the extremely miniaturized components involved in production processes will form a network, actively communicate with each other and, in cooperation with their surroundings, perform planning, coordination and monitoring tasks in a decentralized manner. Sample applications of this technology are designed to showcase the concept of self-organization in the production sphere. Research is focusing on the reconfigurability of process e-grains and robust radio communication in adverse environments.

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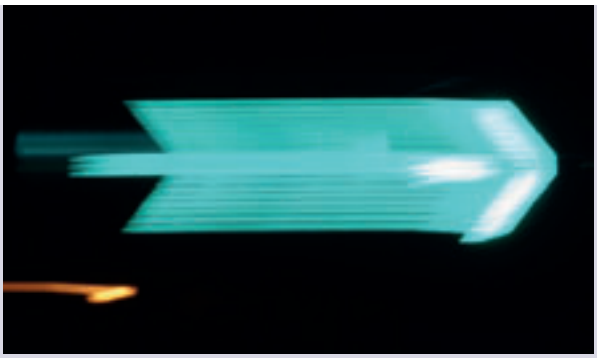
Future expeditions to outer space will need robots that can communicate autonomously with one another.

avoidance. Largely preprogrammed outcomes are characteristic of most of the systems in use today, whose requirements range from "best effort" to maximum possible safety. The dialog is delimited by the fact that not only the task but also its potential solutions must conform to a clearly defined pattern.

Keeping the specific solution open to a certain extent is something that leads to an entirely new dimension in the "dialog of objects" and is still largely unexplored. In this type of approach, a system is formed of a potentially unspecified number of intelligent objects to tackle a task together. This could be important, for instance, when exploring the unknown surface of a new planet using a cooperative group of aerial drones and mobile robots. Since it would take too long to communicate with these robots from Earth, they would need to be able to exchange their observations independently in order, for example, to generate a 3-D map of the terrain as effectively as possible. This calls for autonomous coordination between the robots to ensure that they do not collide with each other when



Organic Computing

Self-organizing green waves

Traffic volumes in today's cities are subject to dynamic and often unpredictable changes. In order to keep traffic flowing at all times, researchers participating in the German Research Foundation's Organic Computing program are developing, among other things, traffic-light control systems that adapt of their own accord to meet changing traffic situations. The control systems automatically optimize their own signal plans and, with the aid of local communication, independently organize green waves so as to guarantee a smooth traffic flow. This not only reduces stopping and waiting times, but also cuts fuel consumption and emissions.

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Mesh sensor networks

Early-warning system for Istanbul

Wireless ad hoc networks represent an important supplement to centrally organized communication infrastructures – especially when sensors are expected to capture and evaluate additional information in real time. Finely meshed networks are particularly good at organizing themselves and adapting to changing conditions, and they have a key role to play, for example, in monitoring geo-relevant processes. One such mesh network was developed by the German Research Foundation's graduate school METRIK: using inexpensive seismometers, it registers and evaluates seismic movements in the Istanbul area, enabling both early warnings and rapid notification of any ensuing damage.

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Multimedia onboard systems unite navigation, Internet and online services in a single unit.

maneuvering and that the information is gathered in the most efficient possible way. An even more difficult task is to cut a path through a hill for a train track and to deposit the excavated earth in a predefined area. The construction robots have to coordinate with each other in a precise manner in order to execute the work and respond to the actual geological conditions encountered within the hill.

This extended application of the "dialog of objects" has interesting side effects, not least the way in which the information collected is handled. The experience gained is stored and can generally be accessed and utilized for all subsequent enterprises. A global repository of knowledge and experience is thus built up that is practically available for all time. The intensity with which research into this most complex form of behavior is being conducted can be gaged by the large number of projects that are examining self-organizing power grids and traffic networks, self-regulating sensor swarms and machines, or "curious" robots.

Swarm Intelligence

The many eyes of the sensor swarm

If moveable platforms equipped with sensors, actuators and intelligent algorithms are put in a position to exchange information, the resulting "swarm" possesses a shared situational awareness and the ability to organize itself. Systems based on swarm intelligence offer important advantages over classical monolithic sensor platforms. Whereas the latter can carry out measurements at only one place at any one time, each element in a swarm is able to monitor spatially and temporally distributed physical phenomena simultaneously from its own particular location. Swarms are, by their very nature, decentralized and redundant – and thus robust when it comes to disturbances and failures.

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Self-exploration

Robots with child-like curiosity

Curiosity can be reduced to a formula. And researchers at the Max Planck Institute for Mathematics in the Sciences are using that formula to program robots to explore their environment and test their freedom of movement in the same way that a child would. The idea is that they learn to adapt flexibly when faced with new tasks. By contrast, the robots currently deployed in industry solve only those tasks for which they have been programmed. But it is not the scientists' intention to have robots roaming around unchecked. Instead, in a self-organizing process, the robot's control system strives to achieve a balance between an information flow high enough to satisfy its curiosity and as accurate a prediction as possible of that information flow.

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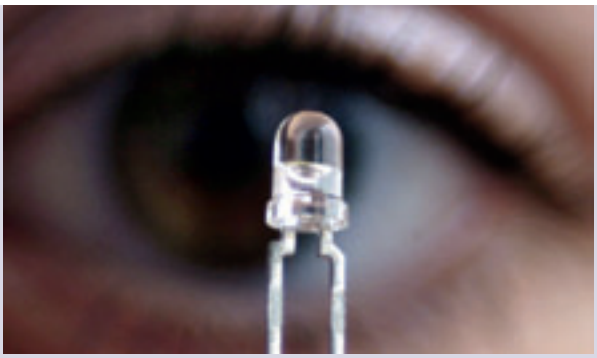
Sensor technology allows body movements to be transferred to digital models in real time.

The examples of communicative objects listed here indicate the diversity of the topic. The components involved can be roughly divided into "passive" or "active" objects. Goods and environmental elements such as the trench cut in a hill and the ice sheet on the road definitely belong to the former category. Sometimes, they exist initially only in a virtual state on a drawing board. In order for them to become reality and be put to a purpose, they first have to be processed by active objects.

Such active objects include industrial robots, motor vehicles or construction machines as well as assigned infrastructure that can communicate with passive objects in order to control how the latter are manufactured, transported or disposed of.

But the borderline between active and passive objects is not clear-cut. Human beings, for instance, occupy a special role – the objects are intended to serve them and they want to be able to communicate with them in as natural a manner as possible.



Optical data transmission
Record transfer rate using LEDs

LEDs are suitable for transferring large amounts of data. Together with colleagues from Siemens AG, researchers at the Fraunhofer Institute for Telecommunications, Heinrich-Hertz-Institut, HHI, succeeded in transferring data at a rate of 500 Mbit/s via a conventional LED manufactured for lighting purposes. Data transmission using visible light communications (VLC) is both license-free and opens up whole new application areas. In the home, it is a useful complement to established wireless LAN technology. One important advantage is that it is interception-proof: only the recipient directly targeted by the beam of light can receive the data. In factories or in the field of medical technology, data has to be transmitted to locations in which it is difficult, if not impossible, to use radio signals – and where lighting is required in any case.

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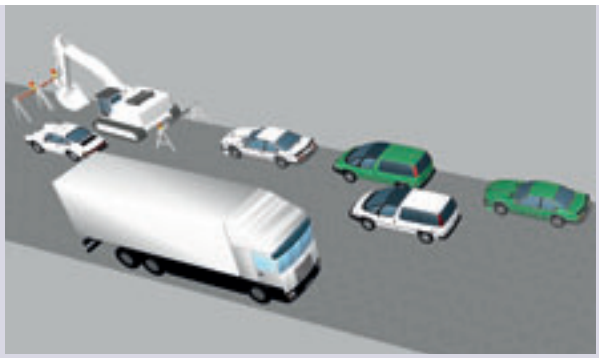

Self-organizing systems / broadband technologies
Avoiding accidents

Serious accidents occur again and again at the tail end of traffic jams, when approaching motorists fail to recognize in time the danger ahead. Maybe new UMTS and LTE wireless infrastructure can help out here? Under the auspices of the CoCar project, the Fraunhofer Institute for Applied Information Technology FIT, Ericsson Eurolabs and the UMIC Cluster of Excellence at RWTH Aachen University are developing automatic data integration and analysis methods to analyze the flow of mobile communications data from onboard software as well as data from occupants' cell phones, using it to take in the traffic situation and issue appropriate warnings. A combination of traffic simulation and data flow analysis software is designed not only to reveal whether dangerous situations can be properly recognized, but also to answer the strategic question of what is required in terms of data quality, type and amount.

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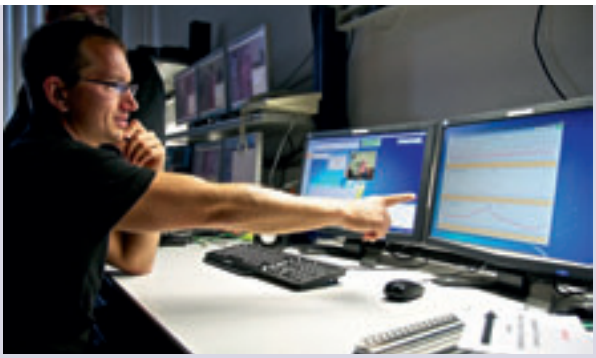
2 Dialog of objects

Information networks ensure the flow and preservation of data and coordinate the actions of active objects.

The usefulness of a "dialog of objects" and the success of communication between people and intelligent objects hinge on a whole array of different factors, in particular on the cost and the size of the objects involved, how they are powered, the available bandwidth, their ability to solve problems and the complexity of the tasks at hand. The necessary degree of communication is determined above all by the intensity of the interaction and cooperation among the objects themselves.

The information network has a crucial role to play in this context, namely to ensure the flow and preservation of data and to coordinate the actions of active objects. It will increasingly also be home to the so-called brokers between objects, which are needed, for instance, to coordinate the supply of and demand for goods and services. Brokers function as trustees, whose task it is to match the transportation or processing wishes of the passive objects to the corresponding offers of the active objects in a way that is both both economical and environmentally sound.



Companion technology

Vending machines with a human touch

Thanks to ever shorter innovation cycles, technical systems such as household appliances, vending machines, cell phones or automobiles are becoming more and more "intelligent." But, due to a lack of user-friendliness and ease of operation, their complex functionality is often too much for ordinary people. Sponsored by the German Research Foundation (DFG), an interdisciplinary research team from the universities of Ulm and Magdeburg is developing companion technology that will allow technical systems to adapt their functionality to fully suit the needs of each individual user. They gear themselves to users' abilities, preferences, requirements and current needs, adapt to take account of their situation and emotional state, and become partner-like service providers.

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Virtual workshop

Designing with gestures and language

People use gestures and language to communicate with each other in an intuitive and natural manner. By contrast, communication between humans and machines via keyboard and mouse can be tiresome. How gestures and language can be exploited in user interfaces is therefore a focal point of research, with product prototypes based on CAD models serving a purpose in this context. Researchers at Bielefeld University have developed a virtual workshop in which language inputs and gestures can be used to design drafts in 3-D computer graphics. Users can interact directly with the drafts to evaluate and, where necessary, adapt them in real time.

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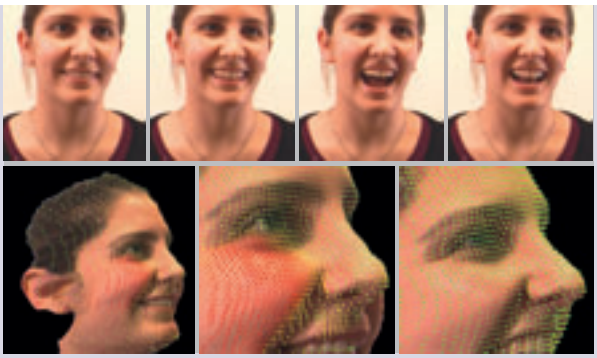
The purpose of the "dialog of objects" is to relieve human beings of work and to offer them new scope for creativity.

Another key aspect is data reduction, which involves striking an ever better balance between the costs and the benefits of data provision. Researchers have only just begun to delve into this area of work.

If this vision of a new, enhanced and more complex dialog is to become reality, standards must be elaborated for communication between objects and for how these objects are represented in the information network, which also includes the data reduction process just mentioned. Rules need to be established for brokers and how they handle the data entrusted to them. The ability to access and pass on information must be subject to control. What is more, there must be legal certainty when it comes to the transmission of intellectual property. Last but not least, the people organizing this form of communication must benefit from it in economic terms. If all this comes about, the "dialog of objects" should indeed relieve people of routine tasks and free them up for more creative activities.



Human-machine interaction

Interactive information management

Ten years ago, digital content was made up predominantly of text; today, it has been expanded to include audio, video and graphics. The challenge this poses consists in organizing, understanding and searching this multimodal information in a robust, efficient and intelligent manner, and creating reliable systems with intuitive multimodal interaction options. This is precisely the task that the Multimodal Computing and Interaction Cluster of Excellence has set itself. In this context, the term "multimodal" is used to describe both the different types of information – text, language, images, video, graphics and high-dimensional data – and the manner of perception and communication – especially through seeing, hearing and human expressions.

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Human-machine communication

Speaking with the voice of a computer

Talking computers could give people who are completely paralyzed as a result of an accident the ability to speak again – if their intentions could be read directly from their brains via electrical conductors. This is the goal being pursued by researchers at the Max Planck Institute for Biological Cybernetics, who are developing instruments and mathematical methods to transform the brain's complex signal patterns into control signals for a machine. They are tapping signals from those parts of the brain that plan and execute movements as well as from those in which information from the auditory system is stored. What is more, the researchers are trying to teach a potential communication aid to learn of its own accord what individual neuronal signal patterns mean.

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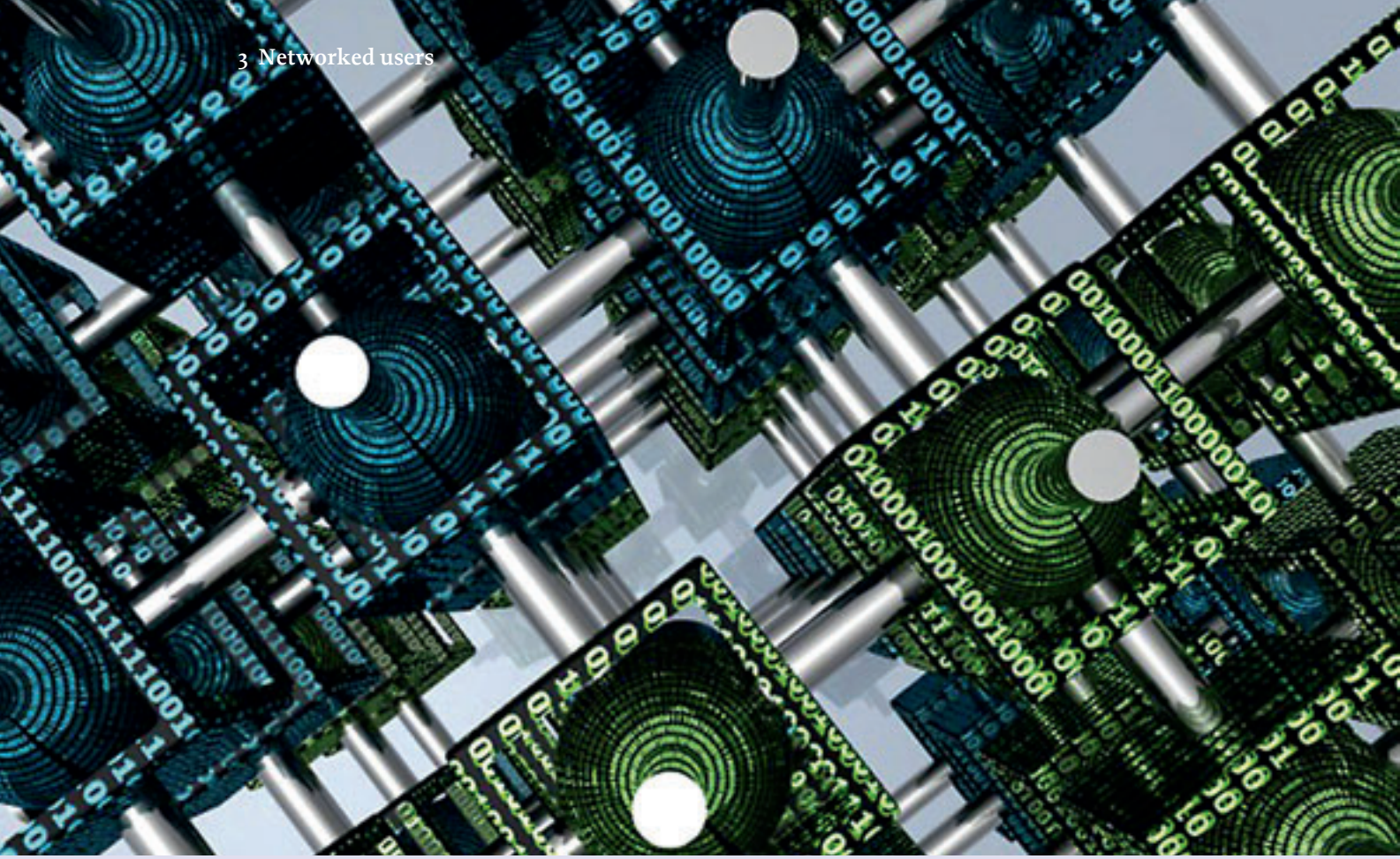

Mobility and digital platforms

Networks and devices are developing at a breathtaking pace, generating ever more services that can give rise to or provide technical support for a multiplicity of communication forms. These services can make our lives easier, more interesting or more comfortable. However, this new dimension in communication brings with it far-reaching changes, the effects of which also need to be examined.

One challenge posed by modern communications technology is to make digital data streams flow faster.

Mobile devices, more sophisticated infrastructure and improved access to information allow us to communicate with each other in a faster, more comprehensive and more spontaneous manner than ever before. According to information from the German Federal Network Agency, two-thirds of private households in Germany are already equipped with a broadband Internet connection, while one-third of those with cell phones use them to access data services on a regular basis. What is more, the growing number of digital media users are becoming more and more connected.

In itself, the technical improvement in communicative data streams in terms of availability, volume and throughput is already the result of intensive R&D work; but it is also the prerequisite for new types of utilization that go beyond mere telephony, television or web browsing. In this way, we are experiencing qualitative changes in three crucial aspects of communication – changes that are opening up fundamentally new possibilities for information, interaction and publication.

Social networks

The methodological underpinnings of Web 2.0

Already, over half the population in the industrialized economies communicates via the social media of Web 2.0. Users of these media generate a prolific stream of data that can provide information on their likings, their behavior vis-à-vis the media and their social relationships – information that arouses interest from many different quarters. But researchers began examining social networks long before the dawn of the Internet era. For this they used a range of tools that has grown over the decades and about whose suitability very little is known. In the "Algorithms of social networks" project funded by the German Science Foundation (DFG), IT specialists from the University of Konstanz are collaborating with sociologists in an effort to narrow the gap between theory and methodology.

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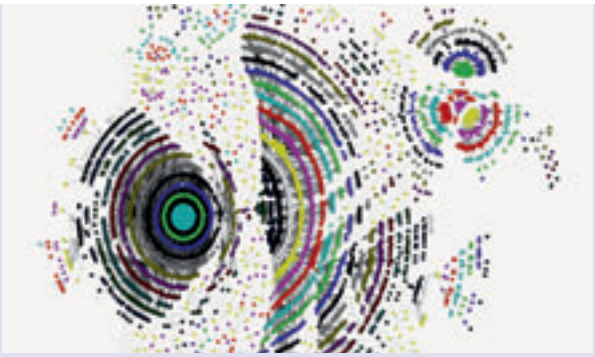

Social networks

The echo of digital tweets

Whether calls for protest following the election of the Iranian president or comments on the election of his counterpart in Germany – many messages are sent first, and sometimes only, via Twitter. How information is disseminated via this social medium and the role played by individual users are topics being examined by researchers from the Max Planck Institute for Software Systems. Their research reveals that the influence of a particular user – for instance a newspaper – does not depend primarily on the number of supporters that follow its tweets. Rather, what is decisive is whether the messages are discussed and forwarded to others. These and other findings will be of use to marketing experts. What is more, epidemiologists can gain useful information from them on the spread of epidemics.

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3 Networked users

Navigation systems physically guide their users through unfamiliar cities.

For a start, mobile devices enable people to communicate pretty much wherever they happen to be: a short-message service like Twitter would be nowhere near as interesting if the messages could be sent only from one's home or a public phone booth. In addition, automatic geopositioning by means of mobile network cells or satellite-based navigation is revitalizing the localized processing and presentation of information and communication. The repertoire includes not only lists of local taxi companies, service stations or restaurants, but also tracking down people who are in danger, or the popular hide-and-seek game of geocaching.

What is more, the ease with which digital content can be stored and copied serves to remove time restrictions above and beyond transmission speeds. This enables spontaneous communication – whether synchronous or asynchronous – between individuals or whole groups of people and services. An online encyclopedia such as Wikipedia would be inconceivable, for instance, without the possibility of collaborative real-

Data transfer
Efficient random communication

Companies with many branch offices often store their data locally so that it can be accessed quickly. When that data is changed, the changes have to be passed on to many branches in a short space of time. That can be accomplished via a cascade, where each station informs the next until all are in the know. But that takes time and is not secure – for if one computer fails to pass on the information, all the following computers in the chain are left high and dry. According to the findings of researchers at the Max Planck Institute for Computer Science, it can make sense to pass on the information not in strict consecutive order, but more randomly. This method is both quick and robust because stations that are down can be bypassed via random detours.

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Software cluster
Innovation for digital companies

In an increasingly digitized business world, corporate software forms the backbone of commercial value chains, and thus has the potential to drive innovation in the majority of industries and in the public sector. The Software Cluster in the region centering on Darmstadt, Walldorf, Kaiserslautern, Karlsruhe and Saarbrücken is busy researching and developing software solutions designed to digitize companies. The partners in this "cluster of excellence," which is funded by the German Federal Ministry of Education and Research (BMBF), include well-known software enterprises as well as research institutes such as the DFKI (German Research Center for Artificial Intelligence) and the Fraunhofer Institutes IESE, IGD, ITWM and SIT.

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Mobile devices have made access to social networks an integral part of life even in the street.

time processing by tens of thousands of users spread across different countries and time zones. A large number of specialized databases and search engines allow people to find information free of the restrictions of the business hours of inquiry offices.

The third – and, in social terms, potentially most exciting – innovation can be seen in the roles of those taking part. Social media are bringing entirely new formats and production conditions to complement the conventional interaction forms of small-group communication and the separation of producer and recipient typical of the traditional media.

Participants in the Web 2.0 world generate content individually or in groups and make it easily accessible for the general public. In turn, the public expands on, links to, discusses and evaluates the content of, for instance, video platforms or music recommendation services, thus creating – almost as a matter of course – interest-driven groups, which observe rules that are different than more traditional and binding social communities.

E-government / e-learning / e-business

Innovation as a global responsibility

Five billion people in structurally weak regions have only very limited access to medical services or education – for the simple reason that they are not online. Developing tailored communication infrastructure for these regions is the goal of the Center for Information and Communication Technologies in Developing Countries (or NET4DC for short), which was founded in 2010 and is coordinated by Fraunhofer FOKUS. To enable people in these regions to utilize services such as e-health, e-learning, e-government, e-commerce or e-microbanking locally, the infrastructure in question often has to be adapted to cope with harsh environmental conditions, irregular power supplies, language problems or a restricted radio frequency spectrum. To this end, researchers are developing large-scale wireless mesh networks and test environments in which the infrastructure's performance and user-friendliness can be optimized.

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E-government

Virtual meeting point for governments and citizens

Particularly in times of declining voter turnout, a direct dialog between governments and those they govern represents one way of resolving what has been termed the "crisis of democracy." What could be more suitable for this purpose than to make use of virtual meeting points on the Internet, to which both sides can easily connect? It is an idea being implemented by an EU project entitled "Where eGovernment meets the eSociety." In order to bring citizens and political decision-makers together, trigger the discussion of current topics and gather citizens' opinions on key issues quickly and easily, the project is exploiting burgeoning Internet-based social networks such as Facebook, Twitter and YouTube.

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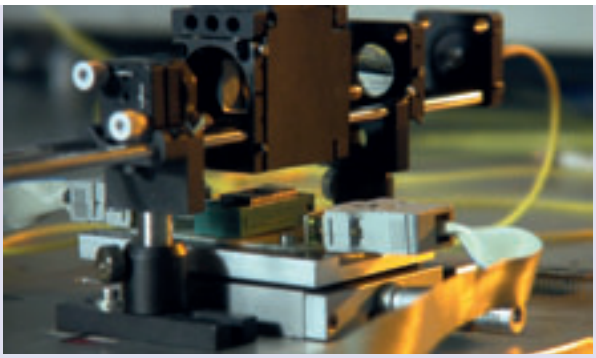
New visualization formats lend virtual transparency to the real world in the interactive Web 2.0.

A range of criteria enable us to distinguish and categorize social media. These include their content and format, but also those participating in them or the conditions under which they are disseminated and utilized. As the examples above make clear, the many possible permutations of these criteria already point to the diversity of digital communication forms – a diversity that is set to increase in future. On top of this, more and more communication tasks are being transferred from their traditional formats to new formats, or are at least being expanded to include new components – e-government and electronic tax returns being just two cases in point. Owing to the central role of communication in our society, these changing conditions impact on many different topics, resulting in a plethora of research fields for science. The changing possibilities are generating innovation potential for the creation and implementation of new services. In addition to independent editing platforms, price engines and auction houses, these services include marketplaces for contract work or private consumer loans.



E-research

Tomorrow's knowledge management

In a joint project, the Max Planck Digital Library and the FIZ Karlsruhe have developed the eSciDoc e-research platform, an open-source platform that can be utilized to create virtual research environments. A sample project is BW-eLabs, in which the FIZ Karlsruhe and the universities of Freiburg and Stuttgart are collaborating to develop a digital platform for managing knowledge in virtual laboratories for nanotechnology and optical lens technology. The goal is to support the entire research process, from planning of the experiments through collection and analysis of data to publication of the final results. This will serve to enhance the transparency and reproducibility of the processes.

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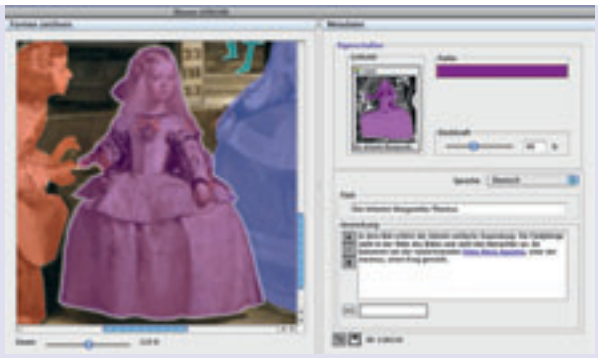

Virtual research environments

Networked images: Meta-Image

The objective of the Meta-Image project being sponsored by the German Research Foundation (DFG) is to provide a web-based research environment for the discourse on artworks between art historians. To this end, prometheus, a distributed digital picture archive at Cologne University, grants users legally secure access to some 750,000 pictures from 59 donating institutions. In combination with software developed at the Leuphana University of Lüneburg and the Humboldt-Universität zu Berlin, Meta-Image enables users to mark and link motifs in the prometheus database and annotate them with hypertext. In this way, both art historians and image and cultural scientists can exploit the opportunities offered by collaborative, network-based image analysis.

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In social networks, everybody is "related" to everybody else via a diverse range of interfaces.

However, these new possibilities are engendering increased interest in monitoring users and evaluating their data, and thus require some degree of oversight and control mechanisms. Viral marketing, political campaigning or the growing tendency of HR departments to expand their knowledge of business partners and applicants via the latters' profiles in social media such as Facebook rank among the less harmful consequences of this trend.

This raises questions over the inherent personal, social and economic effects, both as regards our involvement in the ongoing media networking trend and – increasingly – our exclusion from it. A broad spectrum of academic disciplines is affected, from psychology, sociology, media studies, political science and economics through to telecommunications and IT. But since the crucial questions cannot be answered by any one discipline alone, appropriate interdisciplinary networking remains a key topic in the study of "networked users."

Communication in the sphere of science
Multimedia museum exhibits

Dynamic visualizations, in the form of animation, interactive graphics or digital videos, are becoming increasingly important for communication within the scientific sphere. This also applies to museums and exhibitions. In this field, scientists at Tübingen's ScienceCampus are carrying out R&D work on a multimedia information system. The system enables visitors to "collect" exhibits in virtual form on their iPhones and to display them on a digital multi-touch table. Once the objects are on the table, they can be enlarged, examined and processed intuitively by several people simultaneously. In addition, the visitors can call up more in-depth information on the exhibits.

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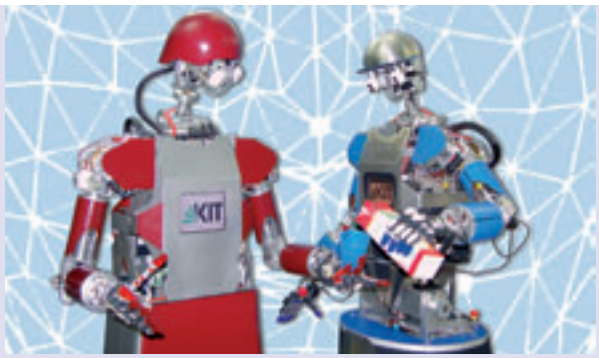

Communication in the sphere of science
Science for the public: Inside Science

Inside Science, a project sponsored by the German Research Foundation (DFG), centers around practicing science in the public arena, with media professionals developing new forms of communication hand in hand with researchers. By means of films – some of them animated – they reveal what science is like below the surface. Different versions of the films address different target groups. Their modular form means that elements can be deployed individually, for example in the classroom. The videos are disseminated via portals, forums and blogs in which the films' producers enter into a dialog with public. Media training sessions help the scientists prepare for their new role in film production.

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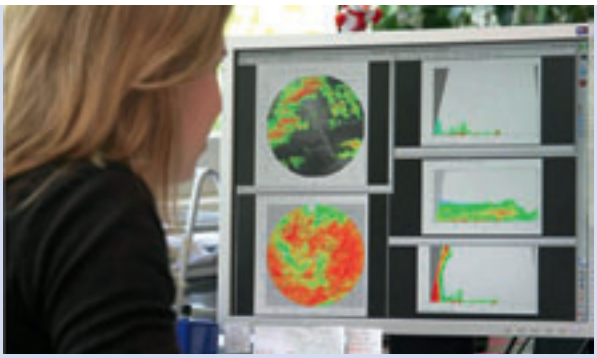
Presentation and processing of information

The structure of the human brain – which is highly networked and capable of learning, and assigns different tasks to different sections – enables us to distinguish between what is important and unimportant, for example, or to imagine a context. Scientists are now in the process of formalizing these abilities and teaching them to machines so that the latter will be able to turn information into knowledge. Computers help us to make proper use of the flood of information confronting us on the Internet, but they also allow the large amounts of data collected by modern measuring instruments to be evaluated. At the same time, the goal is to enable machines to recognize things for themselves and to gain knowledge so that, going forward, they will be able to provide us with reliable and flexible support for a whole array of tasks.

Orientation is key in the media whirlpool.

One can certainly have too much of a good thing. In the digital age, for example, the amount of information available to us is far more than we can properly process. News cycles in the media are getting noticeably faster, not least as a result of ongoing globalization – in a shrinking world, many political and economic developments are interconnected and influence each other. But it is not only the image of reality that is changing, the forms that communication takes are changing too. The Internet is a repository of information on all imaginable topics, which are being disseminated ever faster via social media such as Twitter and Facebook. How users mine the knowledge that is relevant to them from this mass of information poses a challenge, and not just in terms of how we handle the media.

Scientists are facing similar problems. Modern measuring techniques provide them with reams of data that conceal valuable knowledge. The challenge is to uncover that knowledge or, at the very least, to archive the data in a sensible manner. As people cannot process these amounts of data themselves, researchers are looking



Long-term archiving

Climate data for our future

In a project entitled "Integrating the publication of environmental data in the scientific work process," which is funded by the German Science Foundation (DFG), the Bonn-Rhine-Sieg University of Applied Sciences, the Meteorological Institute of Bonn University and the German Climate Computing Center are jointly developing a procedure and a web-based workflow system. These will enhance meteorological research data with additional information and subject it to a quality assurance process in order to make it fit for publication and long-term archiving. The goal is to ensure that high-quality data is available to other researchers – both now and in the future.

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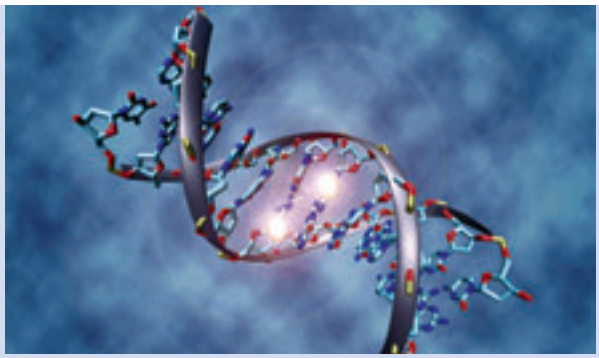

Analysis of high throughput rates

Computerized cancer diagnostics

In order to determine the genetic features of cancer, researchers at the Max Planck Institute for Computer Science are using computer programs that employ statistical methods – which means they can also assist in treating the cancer. They have, for instance, developed a statistical test that can be used to forecast the efficacy of chemotherapy in the treatment of brain tumors. In some patients, a gene for repairing the damage done to the genetic material of the cancer cells by the drugs used in chemotherapy is active. Consequently these patients would not respond to chemotherapy. The computer program allows doctors to determine in advance whether the treatment is likely to be successful or not.

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Those who skillfully deploy Internet media in their communications can better make themselves heard in the world.

to machines for support – machines that can search databases for patterns, particular features or irregularities. Teaching machines to recognize and learn autonomously is becoming a field of research in its own right, one that is of significance in many different contexts: for instance in the endeavor to train robots to recognize information in a complex, changing environment and to respond flexibly to changes.

The Internet, which has fundamentally changed the fabric of society, the economy, scientific work and everyday life, is a prime example of how information can be turned into knowledge. Search engines provide information on virtually any topic, and the Internet has the potential to become the most comprehensive collection of machine-processable knowledge. But knowledge structures in the Internet are amorphous, and search engines rarely provide precise answers to the questions of experts. One challenge lies in successfully making the leap from information – the "raw material" – to the intelligent management of digital knowledge.

Cognitive systems

A classroom for robots

Traditional industrial robots carry out their tasks in strict accordance with a plan. They cannot respond to changes in their environment. But assistance robots in household environments or for supporting the elderly have to be versatile. That is why researchers at the Max Planck Institute for Biological Cybernetics are developing robots that can adapt. Their movements are not hard-wired in their software. Instead, they learn a variety of motion patterns autonomously, selecting the right one within a split second in a given situation. Initially, a robotic arm practices movements with the help of a teacher, who guides it. Then, through a process of trial and error, the robot improves the movements on its own. Machines are already learning to play table tennis, for instance.

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Cognitive systems

Mechanical helpers with brains

Today, people are never without their computers. The next step will be robots that learn, decide and act autonomously and flexibly – helping people in industrial, health care and household environments. For machines to be able to do this, they must be in a position to perceive their surroundings, to learn and to react flexibly. That is why the Cognition for Technical Systems (CoTeSys) Cluster of Excellence, which is being coordinated by the Technische Universität München, is carrying out research into the fundamentals of cognitive science, which include a better understanding of how human beings process information. That is why neurologists, cerebral researchers and psychologists also form part of the CoTeSys team.

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The cornucopia on offer in the Web 2.0 world calls for intelligent semantic structuring.

A number of ongoing research projects are pursuing what has thus far been an elusive goal for artificial intelligence: can we capture the entire knowledge of an educated person and formally map it to a computer in such a way that programs can use it to understand the content of texts and language, draw intelligent conclusions and give precise answers to complex questions? Equipped with this level of knowledge, a computer could successfully compete in quiz shows or enhance the quality of the answers provided by search engines so that they compare favorably with those provided by human experts.

This illustrates the potential of current research projects across the range of topics covering the Semantic Web, Web 2.0 and collective intelligence, or the automatic data mining and linking of knowledge. In the Semantic Web, explicit modeling is used to create knowledge structures. In the online communities of Web 2.0, informal annotations and assessments are made which, after statistical analysis and aggregation, produce more valuable structures at the collective level. Data mining ultimately takes this as the raw material, refining it to design a formal representation of knowledge and linking

The Internet of services

More competitive thanks to web-based services

What impact is the "Internet of services" having on the economy? What is driving and what is hindering its development? And what effects will it have on the competitiveness of companies? These were the questions examined in a study by the Centre for European Economic Research on behalf of the German Federal Ministry of Economics and Technology. The study sought to determine the economic potential of the relevant technologies for Germany as a leading industrial nation. It focused on trends such as cloud computing, software-oriented architectures (SOA) and web services, on the basis of which services can be developed, traded and linked to form new service ecosystems on the Internet.

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The Internet of services

Upgrading the Internet

Developed in the 1970s, the technology underpinning the World Wide Web is no longer able to cope with the Internet's future growth. The challenge faced has less to do with the sheer number of users, which is set grow from today's 1.5 billion to around 4 billion in just a few years, and more to do with the much faster-growing number of devices and programs that network autonomously with each other. To ensure that plans to upgrade the web are are not left entirely to the US and Asia, the EU launched a research program in early 2010 that has since grown to comprise almost 100 public-private partnerships. Germany is represented by Fraunhofer FOKUS, which is primarily contributing its experience with test environments for new infrastructures.

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How to transform confusion into knowledge? This is a question that German scientists, too, are helping to answer.

it precisely with data sources on the Internet. This gives rise to gigantic knowledge bases which are enriched with linked data sources and multimodal content.

One of the exciting applications of knowledge-based computer systems is to rid words – such as names in texts and language – of their ambiguity. In a sentence such as "Page played amazingly on his Gibson" it is unclear a priori who Page is and what a Gibson is. Is it perhaps Larry Page from Google and some new Internet browser? The knowledge of the world formally represented in the computer can help to resolve the ambiguity. Nowadays, comprehensive knowledge bases contain dozens of people with the family name Page, among them Jimmy Page, who belongs to semantic categories such as guitarist and rock musician. They also know that Gibson, among other things, is a prominent brand of electric guitar. From all the possible links between names on the one hand and individuals and concepts on the other, intelligent algorithms calculate the most probable, semantically coherent context, thus identifying Page as the guitarist of rock group Led Zeppelin.

Semantic Web

Helping computers to "understand"

The Research Center for Information Technology (FZI) is developing novel technologies for a future knowledge infrastructure based on the Internet. The project forms part of THESEUS, a major German research program under the auspices of the German Federal Ministry of Economics and Technology. The FZI is examining semantic technologies on the basis of ontologies, which enable computers to "understand" the meaning of content. Ontologies are formal models that represent knowledge in a conceptual form, enabling it to be processed in an automated manner at the semantic level – something previously only possible for human beings. The FZI is developing methods for the creation and efficient management of ontologies.

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Semantic Web

Science community supports data providers

Many of the decisions taken by companies, public authorities or ordinary citizens are based on knowledge gained through the analysis and processing of empirical data records. This is a trend that PlanetData, an EU Network of Excellence, is tracking. The goal of the project is to establish a European community of scientists who will support data providers worldwide in publishing their data sets online in a beneficial way. To this end, technological standards of the Semantic Web are being utilized along with methods and tools to integrate data, analyze them, and make them accessible in a flexible and convenient manner. The project is also setting up training and exchange programs as well as mentoring and careers programs.

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The Internet is a democratic forum, and all are free to contribute to the huge range of content on offer there.

But the spectrum of intelligent applications that profound computer knowledge can make possible goes far beyond just semantic search engines, and encompasses collective recommendations (for instance in the health care field) as well as automatic recognition of objects in images and videos.

Intelligent computer programs can also identify patterns in data records that a human being would fail to notice. For example, appropriate processes for machine learning recognize the genetic patterns that are characteristic for illnesses such as cancer, or can make it possible to predict how well a certain patient will respond to a special therapy.

Extrapolating current research into the future, we soon may well be on the verge of a paradigm shift from the information society to the knowledge society, and a positive change from a flood of data to the intelligent provision of relevant facts and semantic contexts.

Semantic searches

Social navigation in information systems

Many Internet services allow users to "tag" resources. Over time, this results in complex semantic annotations that have been created on a collaborative basis – annotations that are characterized by the document-user-tag trinity. How can this data be utilized? The Department of Neuronal Information Processing at the Technische Universität Berlin is generalizing procedures for what is known as community detection for data of this type, so that documents, users and tags can be grouped according to their links and link density. This makes hierarchical navigation structures possible that are generated and personalized for each user at run time and that can respond flexibly, for instance to new topics.

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Semantic searches

In search of the world's knowledge

People dream of being able to make the sum total of humankind's knowledge accessible to everyone. Thanks to the Internet, this dream seems to be within our grasp. But, to this day, complex searches in the World Wide Web are fraught with problems. For example, the question "Which politicians are also scientists?" merely brings up political statements. Researchers at the Max Planck Institute for Computer Science have brought together long-standing Internet archives, which categorize information very roughly as being either for "scientists" or for "laypersons," with the detailed knowledge of the online encyclopedia Wikipedia. YAGO-NAGA is the name of the software system, which is already running as a prototype and either knows or can derive hundreds of millions of facts. It is the first system that can answer the question "Which researcher survived two world wars and outlived his four children?" The answer is Max Planck.

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Opportunities and risks of digital communication

Digitization will be the key to academic and scientific life in future, playing a crucial role in the preservation and utilization of our past and present cultural heritage. The way in which scientists will be provided with digital research data and publications going forward is a highly topical and complex issue. One of the questions to be resolved concerns the technical and legal requirements for making data available for use in the most egalitarian manner possible.

The digitization of books that are of great value or have already suffered damage helps to secure our cultural legacy.

Master butcher Thomas Schwab stands at the wooden counter of his shop. With his ax held high in the air, he is a study in concentration. The leg of pork before him already has a deep cut in it. In just a moment, he will swing the ax down and hew the piece of meat in two. Sausages and other cuts of meat are on display for the customers. On the right we see a set of scales; on the left, another joint of meat hangs from the wall – such was a butcher shop back in the year 1615.

In order to take a closer look at this illustration from the house books of Nuremberg's "Zwölfbrüderstiftung," you do not need to visit the Nuremberg City Library, where the books are kept. These house books, which constitute a significant source for the history of trades in Germany, were digitized and annotated with descriptions in 2009 in a joint project between the City Library and and the Germanisches Nationalmuseum (GNM) in Nuremberg. The books' 1600 illustrated pages can be called up online by everybody, along with all available information on the persons depicted and key data such

Digital heritage

World culture in 3-D

How can museum exhibits be described more vividly in future than via texts in exhibition catalogs? Will Michelangelo's David soon be rotating as a 3-D image on mobile displays? Questions like this are being addressed by researchers in the European 3D-COFORM Consortium. They are developing new technologies for a virtual archive of the world's cultural heritage. In this way, vases, historic spears and even whole temples can be preserved in the form of 3-D images. This is useful, above all, for scientists and academics, who will have an easier time finding comparable objects. With the aid of intelligent software, for example, it will be possible to view – anywhere in the world – all Greek vases from the 6th century BC that have at least two handles. Even information on the surface texture or color of the objects can be captured in three-dimensional form and researched.

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Digital heritage

DigiPEER – a new dimension in spatial history

The purpose of DigiPEER, a joint project led by the Deutsches Museum Munich, is to digitize some 20,000 valuable plans and technical drawings related to the recording and development of public spaces in the 20th century. Other project participants include the Leibniz Institute for Regional Development and Structural Planning (IRS) in Erkner, the German Mining Museum Bochum and the German Maritime Museum in Bremerhaven. By presenting these many sources from a variety of archives online, the participants hope, among other things, to excite more interest in research into the history of spatial planning. The focus falls on mining, space travel and shipping as well as architectural and regional planning, which have been identified as the central areas of activity in the appropriation of public space in the modern era.

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The reading room of the university library at the Freie Universität Berlin resembles a server room.

as the date of the painting, the technique used and the state of preservation. It is an extremely valuable source of data for academics studying the trades and crafts of the medieval and early modern periods – and its availability in digital form is a good example of how important digitization is for the preservation and exploitation of our cultural heritage.

Portals like this one are generally either limited to a certain topic or restricted to the digital stocks of a single institution. As a result, access to them is possible only via the institution in question, which means that users hunting for sources have to know in advance – or will need to research – the relevant web addresses and the content that can be accessed there. In order to relieve users of this burden, it will in future be possible to access a wide range of digital objects from the cultural and scientific spheres via the German Digital Library (Deutsche Digitale Bibliothek). With the aid of federal and *Länder* funding, a network of institutions from all walks of cultural and scientific life has begun compiling the German Digital Library. The platform on which the

German Digital Library
Digital networking of our cultural legacy

The declared aim of the German Digital Library is to link up information from Germany's cultural and scientific institutions and make it available via a central Internet portal. Fraunhofer IAIS is tasked with the planning, development and technical implementation of the first stage of the project. Together with its project partners, the institute is conceiving the overall technical plan; contributing its expertise in the fields of document analysis and processing, the automatic exploitation, structuring and networking of knowledge, and innovative search programs and presentation techniques; and coordinating all activities related to project implementation.

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Electronic identities
Secure ID cards

On November 1, 2010, a new ID card in credit card format was launched in Germany. The data stored in its chip is protected by state-of-the-art cryptographic methods and transmitted to officially approved bodies in encrypted form only. The new ID card can also be used to confirm the holder's identity in the Internet, for example when submitting applications to public authorities or making purchases. Together with the German Federal Ministry of the Interior, the Fraunhofer Institutes for Open Communication Systems FOKUS and for Secure Information Technology SIT have set up a test and demonstration center for the new ID card in Berlin. The center serves as a contact point for companies and administrative bodies interested in the new ID card.

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Modern scanners can capture images as well as three-dimensional objects.

library runs will be operated by FIZ Karlsruhe – Leibniz Institute for Information Infrastructure.

The way in which scientists will be provided with digital research data and publications in future is a highly topical and complex subject that is currently being worked on under the heading "scientific information infrastructure." In 2009, the Joint Science Conference (GWK) of the federal and *Länder* governments gave the order to formulate a national approach to this matter. The task was assigned to the Commission on the Future of Information Infrastructure, which is chaired by Sabine Brünger-Weilandt of the FIZ Karlsruhe – Leibniz Institute for Information Infrastructure. The commission plans to present a proposal before the end of 2011. Scientific information infrastructure's core task is the provision of information and associated services to the science and research community. The services in question are geared to supporting scientists in obtaining and processing (digital) information and utilizing it on a collaborative basis during all phases of the research process.

Copyright
Who can use knowledge and how?

The IUWIS project, which is funded by the German Research Foundation (DFG), offers an electronic copyright infrastructure for research and education by seizing on the paradigms used in Web 2.0 social media. Many of the problems concerning copyright in the spheres of education and science can be resolved only if a wide range of people and institutions bring their interests to bear. To this end, IUWIS offers pertinent dossiers, for instance on how to create a sound legal basis for the second publication of scientific works. A variety of informational objects are to be collected in these dossiers, with solutions to the problems at hand being developed in teamwork. For this purpose, IUWIS is addressing everyone from the realms of science, education and research, publishing and library science, politics and the media.

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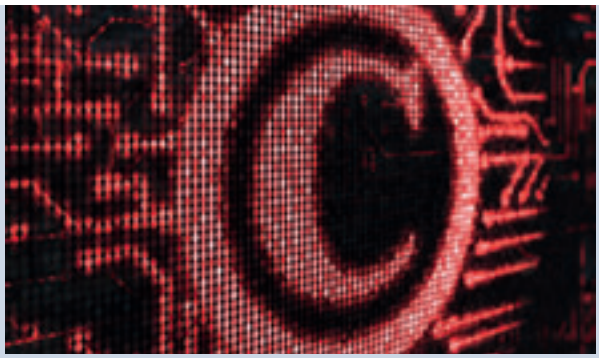

Copyright
Yours, mine or ours? Balancing interests

Pieces of music, poems or academic papers – all of these are accessible to us through the Internet. Users argue for unfettered access in the network of boundless opportunities. Publishers, on the other hand, demand strict protection of copyright, and often pursue this goal on behalf of the authors. Researchers at the Max Planck Institute for Intellectual Property and Competition Law are examining ways out of this dilemma. Their proposals for striking a balance between these interests envisage uniform regulations across Europe. They have come to the conclusion that a revision of copyright laws would not necessarily have a negative impact on the economic situation of the creative class, but would instead allow more competition in the utilization of their work.

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The open access logo.

The idea of "provision" covers a complex spectrum of activities and challenges, the framework for which is comparable in parts with that of an energy provider. In both realms, it is a question of ensuring both a basic service (the prerequisite for maintaining minimum standards) and specialized "high-end" supplies (the prerequisite for achieving excellence); it is about navigating the space between market and state and overcoming the potential mismatch between customer needs or usage demands on the one hand and corresponding supply on the other; and, last but not least, it concerns how we handle resources, i.e. the "refining" of raw materials and their distribution. In this sense, information providers are creating and producing new knowledge. Above and beyond that, they are responsible for the management of information and knowledge.

All this is taking place against the backdrop of a rapidly growing supply of digital offerings (both for payment and for free), such as online scientific databases, Google and its like, printed primary and secondary literature, open-access portals, digital libraries, institutional repos-

Open access
Making research visible – the GIGA Journal Family

The GIGA German Institute of Global and Area Studies in Hamburg has made its four renowned social sciences journals freely available on the web using the peer-review principle, so now every Internet user can access the entire content of the GIGA Journal Family. The journals still appear in printed form in parallel with their online versions. Conversion of the four GIGA journals to the open-access model was sponsored by the German Research Foundation (DFG). The project is so important because it is the only opportunity for GIGA to enter into a dialog with the journals' target regions (Africa, Latin America, China and Southeast Asia) – thus talking with them rather than about them.

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Open access
Old knowledge in new vessels

In the EU project BHL-Europe, which is being coordinated by the Museum für Naturkunde (Museum of Natural History) Berlin, 28 institutions from 14 countries are working to bring together existing European stocks of digitized biodiversity literature. The project aims to make them accessible to a wider public, ensure they are archived in a sustainable manner, and lend support to future digitization projects. Key BHL-Europe products include a global catalog of the partner libraries (GRIB – Global References Index to Biodiversity) and a multilingual portal for searches, reading and for downloading literature. What is more, the literature will also be made available to a broader public via the Europeana platform.

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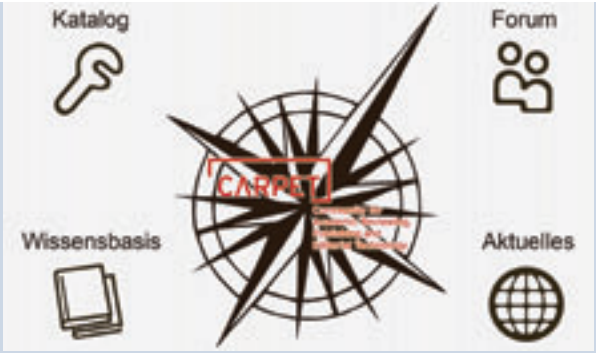
The range of chargeable services, too, is growing rapidly.

itories, etc. Wikis, blogs and services such as Twitter are spreading like wildfire and, more and more, are being integrated in the work processes of the scientific community. Information infrastructure's classic tasks are collecting, storing, licensing and consolidating information, and making the content accessible; ancillary tasks include making the information retrievable, developing and offering retrieval tools, ensuring seamless supply, ongoing assurance of the information's quality and scientific reliability, not to mention guaranteeing its long-term availability.

In addition, new challenges are arising, not least because of the innovative methods employed in the IT sphere. New systems and concepts, for instance, support the semantic linking of different information types and objects, the automatic generation of metadata, and the visualization and standardized dissemination of information. The players actively involved in the process of information procurement no longer include just people and institutions, but, increasingly, systems and autonomous services. As a result, standardization, interoperability via standard interfaces, and integration in the respective local work-



Electronic publishing

Tools for electronic publishing

The ongoing virtualization of the media and work processes is changing the nature of communication in the world of science. The publication process – from production through to utilization and dissemination – is increasingly carried out using electronic means. CARPET, a project funded by the German Research Foundation (DFG), supports the efficient use of electronic tools and services in the publishing of scientific works. To this end, an information platform for e-publishing technology has been put in place, offering a catalog of the software tools and services currently available, a knowledge database and a discussion forum. A central point of entry to the subject helps to bring the different protagonists together.

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Open access

Free access to science

Science for everyone – that is roughly how the goals of the so-called Berlin Declaration can be summed up. The objective of the Declaration on Open Access to Knowledge in the Sciences and Humanities, which was promulgated in Berlin in 2003 by major German research organizations along with numerous scientific and cultural institutions from all over the world, is to make research results and other scientifically relevant material freely accessible on the Internet. Around 300 institutions across the globe have since signed the declaration, underscoring their intention to actively promote, in accordance with the principle of open access, the new possibilities for disseminating knowledge via the Internet. The Max Planck Society supports publication in open-access journals, for example, by bearing the publication fees.

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Testing of two electronic readers for Germany's new ID card.

ing environments (or workflows) of individual scientists and research teams are becoming ever more important. It goes without saying that the science community is making ever greater use of the opportunities for networking that the Internet offers, and this is generating new requirements as regards the availability of information and the options for exploiting it. For example, data is no longer generated in experiments alone, but also in wikis or blogs – which have up to now been a completely "gray" area. Quite apart from technical aspects, many organizational and legal issues will need to be resolved going forward, for instance as concerns copyright and exploitation rights. These challenges will determine the tasks to be tackled in future, which will include, for example: the creation and provision of infrastructures for open-access publications; the collection, storage, exploitation and audit-proofing of primary research data; and the associated tools for storing and making available licensed large-scale journal databases or other digitized publications (hosting).

E-science and e-research are set to play an ever greater role, which creates the task of creating digital working

Data privacy

Better advertising with data privacy

Whenever you click on a web page, the fact that you have is recorded on some company's server. In this way, more and more personal information is being collected via the Internet, information that is primarily used to uphold a constant stream of advertising to Internet users. Now, researchers at the Max Planck Institute for Software Systems have developed a solution for online advertising that takes data privacy into account. It is based on a small program in the browser that analyzes the users' clicks to determine their preferences, but retains the data in their PCs. The program communicates anonymously with the advertisers and only lets through advertising that matches users' preferences. This protects users' privacy and means they receive only advertising of relevance to them.

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Data privacy

Using software to track down data privacy violations

With the growth of online communication and service relationships, it is increasingly difficult for Internet users to ascertain what personal data of theirs has been stored by what companies. The dizzying number of data privacy standards does not make it any easier for users to enforce their right to decide how their data are disclosed. According to a study carried out by researchers at the Karlsruhe Institute of Technology, a mere five percent of providers actually comply with the laws in this area. The researchers are now developing software solutions with which companies or interested Internet users with no special legal knowledge can systematically search for violations of data privacy laws.

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Users leave behind their digital fingerprints when they enter the Internet – that poses challenges for security researchers.

environments that provide researchers with enduring support along the entire science value chain while also allowing them to participate in virtual teams regardless of their location or time zone.

In turn, that gives rise to further challenges. Electronic identities need to be secure, and the protection of intellectual property guaranteed. Digital culture is not a topic restricted merely to science and people looking to publish. Everyone who has a computer workstation or who enters the Internet uses electronic identities – with all their accompanying risks and opportunities. But there is no cause for pessimism. "In a knowledge-based economy, knowledge should flow freely." Those are the words of Jos Engelen, chairman of the Netherlands Organisation for Scientific Research (NWO), spoken in his keynote speech at the conference on Academic Publishing in Europe, which took place at the Berlin-Brandenburg Academy of Sciences and Humanities in 2011. "Sooner or later," says Engelen, free access to the results of publicly funded research "will be the norm and not the exception."

Security on the Internet
Web pages with an expiry date

Party photos on the web are fun and can help students gain recognition from their peers – but probably not from potential employers, who may stumble over the photos years later. That is why researchers at the Max Planck Institute for Software Systems and Saarland University have developed X-pire!, a digital expiry date for pictures on websites, for instance on social media like Facebook. A code is added to the images that makes them publicly accessible for only a fixed period of time. Once the code has expired, the image is no longer displayed correctly. This means future employers will be unable to view such pictures. The software for X-pire! is already available.

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Cryptography
Secure encryption

Without encryption processes and secure digital signatures, many Internet applications – from home banking to online shopping – would be impossible. But ever more aggressive and clever hacker attacks are driving the development of next-generation cryptographic techniques, like the ones at the center of Eike Kiltz's work. Kiltz is a cryptographer and winner of the Alexander von Humboldt Foundation's Sofia Kovalevskaya Award. Together with his team in Bochum, he wants to utilize highly complex mathematical assumptions and algorithms to discover new encryption processes that would be secure, for example, against a quantum computer.

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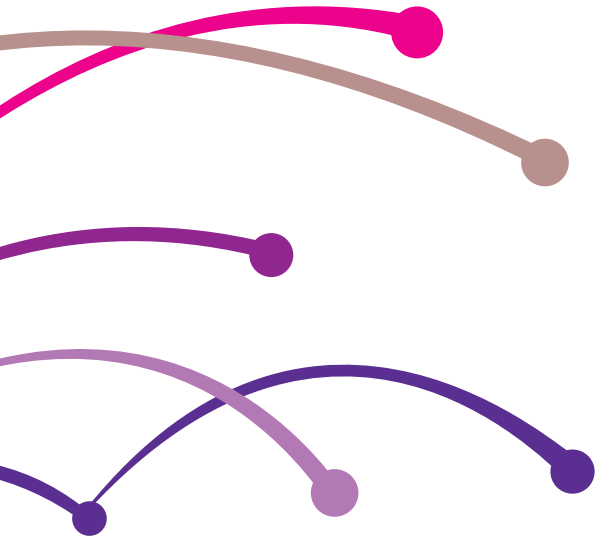

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